ICES WKHAD Report 2006

ICES Advisory Committee on Fisheries Management
ICES CM 2006/ACFM:19

Report of the Workshop on Biological Reference Points for North East Arctic Haddock (WKHAD)

6–10 March 2006

Svanhovd, Norway

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2006. Report of the Workshop on Biological Reference Points for North East Arctic Haddock (WKHAD), 6–10 March 2006, Svanhovd, Norway. ICES CM 2006/ACFM:19. 104 pp.

Contents

1 Opening of the meeting

The Workshop on Biological Reference Points for North East Arctic Haddock (WKHAD) was opened at Svanhovd, Norway at 09:00 6 March 2006 under the chairmanship of Knut Korsbrekke (Norway). Seven out of nine participants attended the whole meeting while the remaining two attended the workshop part time only. The Terms of Reference (Tor) for the Workshop can be found in Annex 3, while the list of participants can be found in Annex 1.

2 Adoption of the agenda

The adopted agenda is given in Annex 2. The adopted agenda is a shortened version of a draft agenda and important issues not addressed in detail in this workshop are:

- Discarding
- Survey catchability issues (varying degree of survey coverage due to yearclass dependent variations in geographical distribution).
- Assessment/prediction error as basis for the estimation of PA reference points (related to the two points mentioned above).
- Age reading issues
- Consequences of implementation error (transshipping of cod and haddock representing unreported landings)

Some of these issues may represent strong limitations in the ability to draw any firm conclusions from the simulation studies.

3 Introduction/background

At the 33rd meeting of the Joint Russian-Norwegian Fisheries Commission (JRNC) in November 2004, the following decision was made:

"The Parties agreed that the management strategies for cod and haddock should take into account the following:

conditions for high long-term yield from the stocks
achievement of year-to-year stability in TACs
full utilization of all available information on stock development

On this basis, the Parties determined the following decision rules for setting the annual fishing quota (TAC) for Northeast Arctic cod (NEA cod):

estimate the average TAC level for the coming 3 years based on F_{pa}. TAC for the next year will be set to this level as a starting value for the 3-year period.

the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development, however the TAC should not be changed by more than +/- 10% compared with the previous year's TAC.

if the spawning stock falls below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{pa} at B_{pa}, to F= 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year, a year before and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

The Parties agreed on similar decision rules for haddock, based on F_{pa} and B_{pa} for haddock, and with a fluctuation in TAC from year to year of no more than +/-25% (due to larger stock fluctuations).” [1]

ICES has evaluated these decision rules for cod and a management plan based upon them is in accordance with the precautionary approach when the SSB is above $\mathbf{B_{lim}}$.

The Workshop is requested to evaluate the agreed HCR in relation to the precautionary approach. The ability to evaluate the HCR is to some extent influenced by the quality of the knowledge of the stock dynamics and the ability to mimic these through simulations. The “quality” of the catch at age matrix for this stock is reflected in a somewhat “noisy” F at age pattern observed in the yearly WG assessment (ICES, 2005a). This in addition to rather “noisy” biological parameters as maturity and weight at age, triggered a revision of input data to form an improved basis for the evaluation of the HCR.

The revision of input data is described in Section 4 of this report. Section 5 is basically a rerun of the WG final XSA run using the revised input data. This was done using both the traditional XSA software (“Lowestoft VPA95.EXE”) and the XSA implementation in FLR (FLXSA). Section 6 is dealing with reference points and how their estimation may be influenced by the revision of the input data. Section 7 contains the evaluation of the agreed HCR. The intention was to do the evaluation using both PROST and a more comprehensive evaluation framework (FLR implementation). The Workshop was in the short time available able to set up only a limited evaluation using PROST.

4 Input data (revising and reviewing)

4.1 Catch at age data

4.1.1 Introduction

Tor a) for WKHAD is “Review and revise input data used in assessing the Northeast Arctic Haddock”. It was decided to limit the updating of these data to the period 1983–2004. For the period 1949–1976, the catch at age data were compiled by Tore Jakobsen, IMR, in 1996 and these data were available to WKHAD. Weight at age data for this period were, however, not available. For the years 1977–1982, at present only catch in tonnes by country, ICES areas and year are available. Age groups 1-14+ were used in the recalculation.

4.1.2 Data sources

Catch in tonnes, catch at age and weight at age data by ICES area and year are available from Norway, Russia, UK and Germany, although some of the countries do not provide such data for years and areas where they have small catches. The Norwegian and Russian data were revised (see below). UK and German age distributions originally reported to AFWG were used in the revision for those years where they were available to WKHAD. For other countries, catch in tonnes as officially reported to ICES have been combined with catch in tonnes as reported directly to Arctic Fisheries Working Group (AFWG).

The Norwegian catch is taken by many gears, with Danish seine, gillnet, longline and trawl being the major gears. Catches by handline, purse seine, shrimp trawl and traps are generally of minor importance. The catch by other countries is almost exclusively taken by trawl. In some years there are minor Russian catches with long-line.

---

1 This quotation is taken from point 5.1, in the Protocol of the 33rd session of The Joint Norwegian-Russian Fishery Commission and translated from Norwegian to English. For an accurate interpretation, please consult the text in the official languages of the Commission (Norwegian and Russian).

4.1.3 Stock definition

Northeast Arctic haddock is caught in ICES areas I, IIa and IIb. Norwegian catches of haddock in ICES area IIa south of 67° N has previously been treated as 'Norwegian coastal haddock', and has not been included in the assessments.

Tagging experiments with haddock released in areas statistical 00 and 05 show recapture in the same areas and in 06 and 07 (Erik Berg, IMR, pers. comm.). Spawning is occurring on the continental slope in areas 06 and 07 in addition to the well-known spawning ground on the western slopes (71°N–74°N). This means that if there is a coastal haddock stock it is likely to show a large overlap with NEA haddock in geographical distribution. Since the stock definitions are based on a weak rationale, we decided to follow common ICES procedure and treat the various potential stocks as one.

Catch in tonnes – statistical areas 06 and 07:

Table 4.1 gives the Norwegian catches in areas 07 and 07. Information for the period 1960–1979 is taken from ICES(1971), ICES(1975) and ICES(1998). The revised values for 1980–2004 are taken from Korsbrekke (2006). Note that the revised values for the years 1980–1982 have not been used to update the time series.

4.1.4 Revision of Norwegian data

The Norwegian data were completely revised. The revision of total catch in tonnes by gear and area is described in Korsbrekke (2006).

4.1.5 Revision of Norwegian catch in tonnes data

Catch in tonnes - data sources:

The data compiled are sales slip data from the Norwegian Directorate of Fisheries together with trawler logbooks. The sales slip data are in some periods aggregated to months adding up all catches within the same statistical area using the same fishing gear. Other periods are more resolved, but with no additional information (basically a number of data lines with only weight of the catch being different). The Directorate of Fisheries has been revising their data as a more or less continuous activity for several years. There have been only negligible changes to the total amount landed, but the proportion of "Norwegian coastal haddock" has seen some minor changes. The changes may be related to the way geographical information is handled. A fishing vessel may operate in several statistical areas and the catches are allocated to the area "dominating" the catches. More detailed information on the geographical distribution of catches is available from the trawler logbooks.

Catch in tonnes - data processing:

A limited number of landings lack the necessary gear code information. These amounts have been redistributed proportionally to gillnet, Danish seine, hand line and long line catches within year, quarter and statistical area.

A small amount of landings is not allocated to statistical areas and has in a similar manner been distributed proportionally between the statistical areas (again within year, quarter and gear category). The geographical distribution of trawl catches from logbooks has been used on the trawler landings instead of the geographical distribution given on the sales slips. The far more detailed logbooks are assumed to better reflect the geographical distribution. The redistribution is within year and quarter.

Landings data:

The Norwegian statistical areas are shown in Figure 4.1. The areas represent a sub-division of the ICES areas I, IIa and IIb. The following table represents the correspondence between Norwegian statistical areas and ICES areas:

ICES	Norwegian statistical areas
I	01 02 03 10 11 13 14 15 16 17 18 24
IIa	00 04 05 06 07 12 30 37 39
IIb	20 21 22 23 25 27

4.1.5.1 Revision of the Norwegian catch-at-age data

The age distributions and weight at age were calculated using the software based on the method of Hirst *et al.* (2005). In this method, the three different data types available are modelled simultaneously using a previously developed Bayesian hierarchical model (Hirst *et al.* 2004). This enables estimation of the catch-at-age with appropriate uncertainty and provides advice on how to best sample data in the future. The data types are random samples of age, length, and weight; age and weight stratified by length; and length only. The model was originally developed for cod, but has now also been applied to haddock.

The data sources are: Samples from the Amigo, the Coast Guard and the Reference fleet.

The Amigo is a research vessel hired by IMR that sails from port to port along the north Norwegian coast over a period of about 6 weeks four times a year (roughly corresponding to the four seasons). At each port, it takes a sample of about 80 fish from any boat available at the time. The length, weight and age of each fish are recorded.

In most cases, the vessels sampled by the Coast Guard are a random sample of the vessels operating within an area, but in a few cases, the inspections may be based on suspicion of illegal fishing. Thus, it might be expected that some of the samples would be biased or unrepresentative for the total catch, although this does not appear to be the case. In general, these samples will only provide length measurements of the fish sampled, although occasionally there are some ages and weights as well.

The reference fleet is a fleet of commercial fishing vessels that have agreed to provide IMR with data on their catch. The reference fleet was started in 2001 with 6 vessels, and in 2004 consisted of 8 vessels. The fleet targets several commercially important species including haddock. This sampling program is developing and will expand in the years ahead. So far, it has consisted of length-only data, but there will be an increasing number of age samples.

The data sources and years used for the model fitting are described in Table 4.2. The resulting catch at age is calculated separately by ICES area and by gear group (trawl, line, other). For some years, the ‘other’ group was not estimated separately, but calculated as the difference between total catches and the sum of trawl and line catches, as indicated in Table 4.2.

The catch at age and weight at age for 2004 by gear and ICES area, with 95% confidence intervals and CVs, is shown in Figure 4.2. Figure 4.3 shows the total catch at age in area IIa, with 95% confidence intervals and CV, for the period 1983–2004.

4.1.6 Revision of Russian catch at age data

The Russian data were slightly revised, but are very similar to those originally reported to AFWG.

4.1.7 Methodology for combining data

The data from the various countries were combined using the SALLOC program (Patterson, 1998). This program uses a fleet (country), time-period and area-disaggregated data storage format for this information, and assembles a total international catch-at-age and weight-at-age data set using defined allocation and interpolation rules where no age distributions are available. The data files used are available together with the report.

4.1.8 Results

The revised data for catch in tonnes by year and area are given in Table 4.3 (AFWG: Table 4.1), and the catch by trawl and other gear for each area in Table 4.4 (AFWG: Table 4.2). The catch in tonnes by year and country is given in Table 4.5 (AFWG: Table 4.3). Tables 4.6 and 4.7 show the discrepancy between the revised data and the data previously used by AFWG. The revised catch in numbers at age and weight at age by year is given in Tables 4.8 and 4.9.

4.1.9 Further work

Although the method for calculating Norwegian catch-at-age seemed to function well, the methodology and results should be thoroughly checked before the 2006 AFWG meeting. Also, the data for third countries should be re-checked.

4.2 Tuning series

There can be a need to revisit/evaluate and possibly revise the survey index series and their use in the assessment of NEA haddock. This is, however not likely to limit the current evaluation of the HCR which use information from the “converged” part of the time series. A revision may change the estimates of the stock status and thus the predictions. This may influence the estimates of the PA reference points (depending on the procedure) and in that respect it has an influence on how future evaluations is set up including influence on performance criteria.

4.3 Biological parameters

4.3.1 Norwegian data

4.3.1.1 Length at age in the stock

Mean length at age was calculated from the Norwegian bottom trawl survey for the period 1980 to 2005. There are large variations, but with clear year class effects. Some ages were missing in some years, and mean length at ages 7 and higher seemed to be rather noisy. A von Bertalanffy function was fitted to the data:

$$L = L_\infty - L_\infty \cdot e^{\left(-K_Y\left(A-A_0\right)\right)}$$

with L and A being the length and age variables. L_∞ and A_0 are the traditional parameters, while K_Y is dependent on year class.

The mean length at age data is shown in Table 4.9 and in Figure 4.4, while the fitted length at age data is shown in Table 4.10 and Figure 4.5. The fitted length at age data seems to capture the variations in growth and the apparent year class effect quite well.

4.3.1.2 Weight at age in the stock

The weight data was scarcer in the Norwegian bottom trawl survey in the 80’s with some years missing weight data all together. Where weight data is available they can be fitted very well with:

$$W = \alpha \cdot L^{\beta}$$

This relationship was then used on the already fitted length at age data and the results can be seen in Table 4.12 and in Figure 4.6.

4.3.1.3 Maturity at age data

Maturity at age was also estimated from the Norwegian bottom trawl survey. Proportions mature at age in the period 1980 to 2005 are shown in Table 4.13 and in Figure 4.7. It is difficult to distinguish any trends and the occasional year class having a reduced proportion mature relative to the previous year is contributing to the overall picture of “noisy” data. The data was “smoothed” by fitting a logistic function using both age and length as explanatory variables:

$$\log\left(\frac{m}{1-m}\right) = I + \alpha A + \beta L$$

Alternative estimations using Age as a categorical variable revealed that the parameters were very close to linear in age. The smoothed maturity ogives are shown in Table 4.14 and in Figure 4.8.

4.3.2 Russian data

4.3.2.1 Length at age in the stock

Mean length at age was calculated from the Russian bottom trawl survey for the period 1982 to 2004. A von Bertalanffy function was used for smoothing the data (the same formula as one used for Norwegian data). The mean length-at-age data is shown in Table 4.15 and Figure 4.9, while the smoothed length-at-age data is shown in Table 4.17 and Figure 4.10.

4.3.2.2 Weight at age in the stock

The weight at age data from the Russian bottom trawl survey are available since 1982 (Table 4.16) with missing data for some particular ages in some years. The weight data have been fitted using smoothed length and using the same formula as the one used for Norwegian data. These results can be seen in Table 4.18 and Figure 4.11.

4.3.2.3 Russian maturity at age data

A maturity ogive was available from Russian bottom trawl survey for the period 1983–2004. The data was smoothed by fitting a logistic function using age and year class dependent *age at 50%* maturity as explanatory variables:

$$Mat = \frac{1}{1 + e^{(-a*(age - age50\%)}}$$

The raw and smoothed maturity ogives are shown in Tables 4.19 and 4.20 and Figures 4.12 and 4.13.

4.3.3 Combined data

The Norwegian and Russian biological parameters presented in Sections 4.3.1 and 4.3.2 was combined as plain averages. One could question whether this is a useful approach as one of the data sources may better reflect the stock than the other. Both sources could have their bias related to age reading issues, and a similar bias could then be found in the catch data parameters. Since catch data are added together (with their respective biases included) and

Norway and Russia are catching approximately half of catch each, a plain average of the two data sources would potentially contain the same level of bias. Such biases related to age reading issues can be assumed to be constant over time and the workshop chose to assume that these issues would not have any effects on the conclusions of this workshop.

The mean weights at age in the stock and maturity at age for the time period 1950 to 1979 was calculated as the average mean weights at age and maturity at age for the period 1980 to 2004. The average natural mortality including predation from cod for the period 1984 to 2004 was used for the period 1950 to 1983.

Weight at age in the stock is presented in Table 4.21 and illustrated in Figure 4.14. Proportions mature at age are given in Table 4.22 and plotted in Figure 4.15.

Table 4.1 Landings haddock (tonnes)

Division IIa- Norwegian statistical areas 06 and 07

Year	Norway
1960	5 943
1961	4 031
1962	3 293
1963	4 285
1964	6 460
1965	6 217
1966	5 223
1967	3 181
1968	2 766
1969	2 120
1970	*
1971	*
1972	*
1973	*
1974	10 000
1975	6 000
1976	2 000
1977	2 000
1978	2 000
1979	6 000
1980	5 098
1981	4 767
1982	3 335
1983	3 112
1984	3 803
1985	3 583
1986	4 021
1987	3 194
1988	3 756
1989	4 701
1990	2 912
1991	3 045
1992	5 634
1993	5 559
1994	6 311
1995	5 444
1996	5 126
1997	5 987
1998	6 338
1999	5 743
2000	4 536
2001	4 542
2002	6 898
2003	4 279
2004	3 743

Table 4.2 Data sources and years used for the catch at age model.

year	data sources used	years used for model fitting	gear/ season effects included	other-group calculated separately	burn-in, samples	weights
1983	Am	1983-1985	yes	yes	500	W = 1.788e-5 * L^2.8575 * 1000 + N(0,0.2)
1984	Am	1983-1985	no	yes	500	W = 1.788e-5 * L^2.8575 * 1000 + N(0,0.2)
1985	Am	1985	yes	yes	500	W = 1.788e-5 * L^2.8575 * 1000 + N(0,0.2)
1986	Am	1985-1987	yes	yes	500	W = 1.788e-5 * L^2.8575 * 1000 + N(0,0.2)
1987	Am	1987	yes	yes	500	W = 1.788e-5 * L^2.8575 * 1000 + N(0,0.2)
1988	Am	1988-1990	yes	yes	500	observed
1989	Am	1988-1990	yes	yes	500	observed
1990	Am	1990	yes	yes	500	observed
1991	Am	1991	yes	yes	500	observed
1992	Am	1992	yes	yes	500	observed
1993	Am	1993	yes	yes	500	observed
1994	Am	1994	yes	yes	500	observed
1995	Am	1995	yes	yes	500	observed
1996	Am	1996	yes	no	1000	observed
1997	Am	1997	yes	no	1000	observed
1998	Am	1998	yes	no	1000	observed
1999	Am	1999	yes	no	500	observed
2000	Am+Co	2000	yes	no	500	observed
2001	Am+Co+Re	2001	yes	no	500	observed
2002	Am	2002	yes	no	500	observed
2003	Am+Co+Re	2003	yes	yes	500	observed
2004	Am+Co+Re	2004	yes	yes	500	observed

Am = Amigo

Co = Coast guard

Re = Reference fleet

no => calculated as others = total - trawl - line

Table 4.3 (AFWG: Table 4.1) North-East Arctic HADDOCK. Total nominal catch (t) by fishing areas.

(Data provided by Working Group members).

Year	Sub-area I	Division IIa	Division IIb	Total
1960	125 026	27 781	1 844	154 651
1961	165 156	25 641	2 427	193 224
1962	160 561	25 125	1 723	187 408
1963	124 332	20 956	936	146 224
1964	79 262	18 784	1 112	99 158
1965	98 921	18 719	943	118 578
1966	125 009	35 143	1 626	161 778
1967	107 996	27 962	440	136 397
1968	140 970	40 031	725	181 726
1969	89 948	40 306	566	130 820
1970	60 631	27 120	507	88 257
1971	56 989	21 453	463	78 905
1972	221 880	42 111	2 162	266 153
1973	285 644	23 506	13 077	322 226
1974	159 051	47 037	15 069	221 157
1975	121 692	44 337	9 729	175 758
1976	94 054	37 562	5 648	137 264
1977	72 159	28 452	9 547	110 158
1978	63 965	30 478	979	95 422
1979	63 841	39 167	615	103 623
1980	54 205	33 616	68	87 889
1981	36 834	39 864	455	77 153
1982	17 948	29 005	2	46 955
1983	5 837	16 859	1 904	24 600
1984	2 934	16 683	1 328	20 945
1985	27 982	14 340	2 730	45 052
1986	61 729	29 771	9 063	100 563
1987	97 091	41 084	16 741	154 916
1988	45 060	49 564	631	95 255
1989	29 723	28 478	317	58 518
1990	13 306	13 275	601	27 182
1991	17 985	17 801	430	36 216
1992	30 884	28 064	974	59 922
1993	46 918	32 433	3 028	82 379
1994	76 748	50 388	8 050	135 186
1995	75 860	53 460	13 128	142 448
1996	112 749	61 722	3 657	178 128
1997	78 128	73 475	2 756	154 359
1998	45 640	53 936	1 054	100 630
1999	38 291	40 819	4 085	83 195
2000 .	25 931	39 169	3 844	68 944
2001	35 072	47 245	7 323	89 640
2002	40 721	42 774	12 567	96 062
2003	53 653	43 564	8 483	105 700
2004 [1]	64 873	47 483	12 146	124 502

[1] Provisional figures, Norwegian catches on Russian quotas are included

Table 4.4 (AFWG: Table 4.2) North-East Arctic HADDOCK.

Total nominal catch ('000 t) by trawl and other gear for each area.

	Sub-area I		Division IIa		Division IIb	
Year	Trawl	Others	Trawl	Others	Trawl	Others
1967	73.7	34.3	20.5	7.5	0.4	-
1968	98.1	42.9	31.4	8.6	0.7	-
1969	41.4	47.8	33.2	7.1	1.3	-
1970	37.4	23.2	20.6	6.5	0.5	-
1971	27.5	29.2	15.1	6.7	0.4	-
1972	193.9	27.9	34.5	7.6	2.2	-
1973	242.9	42.8	14.0	9.5	13.1	-
1974	133.1	25.9	39.9	7.1	15.1	-
1975	103.5	18.2	34.6	9.7	9.7	-
1976	77.7	16.4	28.1	9.5	5.6	-
1977	57.6	14.6	19.9	8.6	9.5	-
1978	53.9	10.1	15.7	14.8	1.0	-
1979	47.8	16.0	20.3	18.9	0.6	-
1980	30.5	23.7	14.8	18.9	0.1	-
1981	18.8	17.7	21.6	18.5	0.5	-
1982	11.6	11.5	23.9	13.5	-	-
1983	3.6	2.2	8.7	8.2	0.2	1.7
1984	1.6	1.3	7.6	9.1	0.1	1.2
1985	24.4	3.5	6.2	8.1	0.1	2.6
1986	51.7	10.1	14.0	15.8	0.8	8.3
1987	79.0	18.1	23.0	18.1	3.0	13.8
1988	28.7	16.4	34.3	15.3	0.6	0.0
1989	20.0	9.7	13.5	15.0	0.3	0.0
1990	4.4	8.9	5.1	8.2	0.6	0.0
1991	9.0	8.9	8.9	8.9	0.2	0.2
1992	21.3	9.6	11.9	16.1	1.0	0.0
1993	35.3	11.6	14.5	17.9	3.0	0.0
1994	58.6	18.2	26.1	24.3	7.9	0.2
1995	63.9	12.0	29.6	23.8	12.1	1.0
1996	98.3	14.4	36.5	25.2	3.4	0.3
1997	57.4	20.7	44.9	28.6	2.5	0.3
1998	26.0	19.6	27.1	26.9	0.7	0.3
1999	29.4	8.9	19.1	21.8	4.0	0.1
2000	20.1	5.9	18.8	20.4	3.7	0.1
2001	28.4	6.7	23.4	23.8	7.0	0.3
2002	30.5	10.2	19.5	23.3	12.5	0.1
2003 [1]	42.7	10.9	21.9	21.7	8.1	0.4
2004 [1]	52.4	12.5	27.0	20.5	11.5	0.6

[1] Provisional

Table 4.5 (AFWG: Table 4.3) North-East Arctic HADDOCK. Nominal catch (t) by countries
Sub-area I and Divisions IIa and IIb combined. (Data provided by Working Group members).

Year	Faroe Islands	France	German Dem.Re.	Fed. Re. Germ.	Norway	Poland	United Kingdom	Russia[2]	Others	Total
1960	172	-	-	5 597	46 263	-	45 469	57 025	125	154 651
1961	285	220	-	6 304	60 862	-	39 650	85 345	558	193 224
1962	83	409	-	2 895	54 567	-	37 486	91 910	58	187 408
1963	17	363	-	2 554	59 955	-	19 809	63 526	-	146 224
1964	-	208	-	1 482	38 695	-	14 653	43 870	250	99 158
1965	-	226	-	1 568	60 447	-	14 345	41 750	242	118 578
1966	-	1 072	11	2 098	82 090	-	27 723	48 710	74	161 778
1967	-	1 208	3	1 705	51 954	-	24 158	57 346	23	136 397
1968	-	-	-	1 867	64 076	-	40 129	75 654	-	181 726
1969	2	-	309	1 490	67 549	-	37 234	24 211	25	130 820
1970	541	-	656	2 119	37 716	-	20 423	26 802	-	88 257
1971	81	-	16	896	45 715	43	16 373	15 778	3	78 905
1972	137	-	829	1 433	46 700	1 433	17 166	196 224	2 231	266 153
1973	1 212	3 214	22	9 534	86 767	34	32 408	186 534	2 501	322 226
1974	925	3 601	454	23 409	66 164	3 045	37 663	78 548	7 348	221 157
1975	299	5 191	437	15 930	55 966	1 080	28 677	65 015	3 163	175 758
1976	536	4 459	348	16 660	49 492	986	16 940	42 485	5 358	137 264
1977	213	1 510	144	4 798	40 118	-	10 878	52 210	287	110 158
1978	466	1 411	369	1 521	39 955	1	5 766	45 895	38	95 422
1979	343	1 198	10	1 948	66 849	2	6 454	26 365	454	103 623
1980	497	226	15	1 365	66 501	-	2 948	20 706	246	92 504
1981	381	414	22	2 402	63 435	**Spain**	1 682	13 400	-	81 736
1982	496	53	-	1 258	43 702	-	827	2 900	-	49 236
1983	428	-	1	729	22 364	139	259	680	-	24 600
1984	297	15	4	400	18 813	37	276	1 103	-	20 945
1985	424	21	20	395	21 272	77	153	22 690	-	45 052
1986	893	12	75	1 079	52 313	22	431	45 738	-	100 563
1987	464	7	83	3 105	72 419	59	563	78 211	5	154 916
1988	1 113	116	78	1 323	60 823	72	435	31 293	2	95 255
1989	1 217	-	26	171	36 451	1	590	20 062	-	58 518
1990	705	-	5	167	20 621	-	494	5 190	-	27 182
1991	1 117	-	**Greenld**	213	22 178	-	514	12 177	17	36 216
1992	1 093	151	1 719	387	36 238	38	596	19 699	1	59 922
1993	546	1215	880	1 165	40 978	76	1 802	35 071	646	82 379
1994	2 761	678	770	2 412	71 171	22	4 673	51 822	877	135 186
1995	2 833	598	1 097	2 675	76 886	14	3 111	54 516	718	142 448
1996	3 743	6	1 510	942	94 527	669	2 275	74 239	217	178 128
1997	3 327	540	1 877	972	103 407	364	2 340	41 228	304	154 359
1998	1 903	241	854	385	75 108	257	1 229	20 559	94	100 630
1999	1 913	64	437	641	48 182	652	694	30 520	92	83 195
2000	631	178	432	880	42 009	502	747	22 738	827	68 944
2001	1 210	324	553	554	49 067	1 497	1 068	34 307	1060 [3]	89 640
2002	1 564	297	858	627	52 247	1 505	1 125	37 157	682	96 062
2003	1 959	382	1 363	918	56 485	1 330	1 018	41 142	1103	105 700
2004 [1]	2 484	103	1 680	823	62 192	54	1 250	54 347	1569	124 502

[1] Provisional figures, Norwegian catches on Russian quotas are included.

[2] USSR prior to 1991.

[3] Corrected

Table 4.6 Catch in numbers - ratio revised numbers/old numbers

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1983		2.168	1.666	1.366	1.538	1.742	0.763	1.986	5.141	1.001	1.695
1984		3.052	2.844	1.235	2.316	2.181	1.267	1.187	0.720	1.263	0.271
1985	4.210	1.290	1.003	1.470	1.033	1.412	2.985	1.398	1.344	1.413	2.485
1986	5.274	0.941	0.903	1.113	1.545	2.082	2.589	2.729	2.381	2.363	6.285
1987	1.110	0.541	1.281	0.987	1.227	1.638	2.882	3.054	2.860	1.936	2.590
1988		3.022	1.812	1.382	0.941	1.050	1.040	2.743	2.125	2.008	1.440
1989		1.234	2.064	1.268	1.312	1.104	0.939	0.597	0.086	0.788	2.688
1990	0.297	1.521	1.968	2.204	1.148	0.981	0.924	0.990	0.344	0.845	2.360
1991	1.083	1.621	1.114	1.812	1.281	1.147	1.043	0.894	1.159	3.948	3.196
1992	0.039	1.047	0.938	0.914	1.700	1.518	1.398	1.270	1.278	2.017	4.685
1993	4.256	0.598	1.007	0.751	1.042	1.474	1.796	1.454	0.988	0.977	0.840
1994	8.657	0.506	1.107	1.093	1.114	1.592	1.264	1.367	1.273	1.577	1.117
1995	0.072	0.435	1.562	1.247	1.023	0.947	1.909	2.033	1.225	1.722	1.637
1996	0.504	1.216	1.025	1.237	1.048	1.038	1.302	1.562	1.373	1.298	1.543
1997	0.935	0.371	1.040	0.932	1.095	1.016	1.046	1.231	1.468	1.338	1.395
1998	49.770	0.725	0.705	0.830	1.127	1.182	1.150	1.093	1.892	1.455	2.159
1999	0.765	1.259	0.828	1.041	0.943	1.053	1.250	0.896	2.245	2.536	3.209
2000	0.522	1.182	1.618	0.999	1.190	1.147	1.427	1.374	1.129	0.953	1.337
2001	10.106	2.115	1.080	0.993	0.910	1.305	1.192	1.284	2.355	1.368	1.187
2002	0.995	1.140	1.160	1.009	1.286	1.262	1.374	1.401	1.697	1.740	1.210
2003	8.761	2.306	1.438	1.017	1.121	2.076	2.062	2.399	6.799	5.419	2.505
2004		1.697	1.130	1.075	1.034	0.978	1.294	1.428	1.475	3.267	1.782

Table 4.7 Weight in catch - ratio revised value/old value

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1983			0.680	0.757	0.814	0.903	0.863	0.825	0.830	0.836	0.836
1984			0.776	0.820	0.842	1.064	0.971	0.955	0.974	0.922	0.864
1985			0.908	0.777	0.760	0.802	0.796	0.880	0.879	0.844	0.818
1986			0.711	0.851	0.819	0.807	0.888	0.919	0.878	0.826	0.978
1987			0.776	0.890	0.886	0.703	0.717	0.856	0.813	0.774	0.780
1988			0.947	1.080	1.045	0.949	0.780	0.676	0.649	0.545	0.476
1989			0.856	0.943	0.853	0.858	0.904	0.852	0.527	0.485	0.497
1990	1.276	0.939	0.890	0.960	0.998	1.015	1.065	0.978	0.717	0.703	0.618
1991			1.222	0.978	0.966	0.966	0.968	0.888	0.789	1.191	0.596
1992	1.378	1.636	1.078	0.929	0.903	0.892	0.892	0.921	0.991	0.866	0.845
1993	4.230	2.134	1.593	1.136	0.978	0.950	0.915	0.972	0.959	1.005	0.973
1994	1.110	1.184	1.136	1.029	0.967	0.921	0.955	0.936	0.956	0.986	1.001
1995	1.359	1.439	1.172	1.224	1.045	0.926	0.871	0.955	0.905	0.894	1.036
1996	2.874	1.780	1.067	1.099	1.004	1.017	0.945	0.824	0.959	0.745	1.021
1997	4.079	1.473	1.034	1.038	1.056	1.122	1.106	0.933	0.917	1.106	0.857
1998	3.412	1.118	1.053	1.083	0.994	1.038	1.066	1.041	0.873	0.930	1.049
1999	4.351	3.023	1.132	1.018	0.993	0.958	0.984	1.004	0.986	0.860	0.951
2000	3.778	2.061	1.422	1.088	1.004	0.999	0.994	1.041	1.094	1.088	1.121
2001	3.556	1.961	1.192	1.138	1.042	0.971	0.985	1.024	1.005	1.083	1.164
2002	1.530	1.406	1.225	1.015	0.971	0.980	0.908	0.920	0.826	0.963	0.991
2003	2.821	1.396	0.963	0.982	0.804	0.763	0.623	0.802	0.607	0.555	0.661
2004	4.824	1.118	1.005	0.996	1.034	1.019	0.969	0.980	0.922	0.969	1.095

Table 4.8 Revised catch at age data

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1983	3	351	1173	2636	1360	2394	2506	1799	267	37	292
1984	7	754	1271	1019	1899	657	950	2619	352	87	77
1985	4	2952	29624	1695	564	1009	943	886	1763	588	281
1986	506	650	23113	68429	1565	783	896	393	702	1144	987
1987	9	83	5031	87170	64556	960	597	376	212	230	738
1988	7	139	1439	12478	47890	20429	397	178	74	88	446
1989	611	221	2157	4986	16071	25313	3198	147	1	28	177
1990	2	446	1015	2580	2142	4046	6221	840	134	42	71
1991	23	533	4421	3564	2416	3299	4633	3953	461	83	54
1992	49	2793	11571	11567	4099	2642	2894	3327	3498	486	84
1993	498	272	13487	19457	13704	4103	1747	1886	2105	1965	323
1994	95	187	3374	47821	36333	13264	2057	903	1453	2769	2110
1995	2	85	2003	16109	72644	19145	6417	746	361	770	1576
1996	35	478	1662	6818	36473	73579	13426	2944	573	365	1897
1997	70	94	2280	5633	12603	32832	49478	5636	778	245	748
1998	547	1476	1701	11304	9258	8633	13801	19469	2113	330	490
1999	104	568	16839	8039	15365	6073	4466	6355	6204	647	446
2000	46	692	1520	29986	6496	5149	2406	1657	1570	1744	437
2001	374	1758	12971	5230	32049	5279	2941	1137	1161	1169	1204
2002	39	441	5491	35584	9290	19917	2269	1425	443	409	917
2003	123	507	4743	20251	44162	10353	13653	1521	2128	829	1137
2004	58	986	5232	13764	28539	34811	4567	4767	569	1215	857

Table 4.9 Revised weight at age in the catch

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1983	0.188	0.689	1.033	1.408	1.710	2.149	2.469	2.748	3.069	3.687	4.516
1984	0.408	0.805	1.218	1.632	2.038	2.852	2.845	3.218	3.605	4.065	4.667
1985	0.319	0.383	0.835	1.290	1.816	2.174	2.301	2.835	3.253	3.721	4.416
1986	0.218	0.325	0.612	1.064	1.539	1.944	2.362	2.794	3.250	3.643	5.283
1987	0.143	0.221	0.497	0.765	1.179	1.724	2.135	2.551	3.009	3.414	4.213
1988	0.279	0.551	0.550	0.908	1.097	1.357	1.537	1.704	2.403	2.403	2.571
1989	0.258	0.550	0.684	0.840	0.998	1.176	1.546	1.713	1.949	2.140	2.685
1990	0.319	0.601	0.793	1.172	1.397	1.624	1.885	2.112	2.653	3.102	3.338
1991	0.216	0.616	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.219
1992	0.055	0.458	0.906	1.263	1.535	1.747	2.043	2.200	2.298	2.494	2.652
1993	0.381	0.640	0.940	1.204	1.487	1.748	1.994	2.237	2.417	2.654	3.026
1994	0.278	0.521	0.614	0.906	1.287	1.602	1.968	2.059	2.390	2.545	2.893
1995	0.258	0.446	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	3.130
1996	0.287	0.427	0.683	0.868	1.045	1.363	1.710	1.886	2.214	2.370	2.675
1997	0.408	0.575	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.500	2.554
1998	0.409	0.593	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.810
1999	0.435	0.695	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.712
2000	0.378	0.577	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.892
2001	0.391	0.647	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.981
2002	0.159	0.433	0.714	1.014	1.363	1.630	1.948	2.074	2.252	2.413	2.737
2003	0.198	0.381	0.587	0.846	1.049	1.309	1.303	1.909	1.593	1.828	2.312
2004	0.328	0.468	0.654	0.897	1.190	1.507	1.803	2.047	2.292	2.554	2.955

Table 4.10 Mean length at age from the Norwegian bottom trawl survey in February.

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	15.9	22.6	30.3	39.1	46.0	57.1					
1981	11.6	25.0	33.8	40.9	51.8	55.7	65.5				
1982	14.4	22.1	31.8	37.6	49.1	56.2	60.1	64.3			
1983	16.5	24.7	35.1	45.0	52.2	58.4	62.6	65.6			
1984	16.5	26.8	32.7	47.8	57.1	63.4	62.5	65.4	65.9		
1985	15.6	24.1	35.5	42.2	58.3	62.8	63.8	68.3	71.6	72.4	69.0
1986	15.2	22.4	31.5	43.0	54.7	55.0	65.0	67.0		66.0	
1987	15.6	22.5	29.0	36.8	46.6					50.0	
1988	13.8	23.9	28.8	34.2	41.7	48.3	56.6				
1989	15.8	23.2	30.9	36.5	41.6	46.3	53.0	57.5			
1990	15.7	24.8	32.6	43.6	46.1	50.1	52.5	55.8	61.4	55.0	
1991	16.7	24.1	36.3	45.0	48.8	52.1	55.6	55.4	61.6		
1992	15.1	24.0	34.2	45.2	53.3	59.2	60.6	60.4	61.3	79.0	
1993	14.5	21.2	31.7	42.4	50.4	56.3	59.3	66.2	63.4	66.4	61.9
1994	14.6	21.0	30.0	38.7	47.6	54.3	57.4	63.4	69.6	65.4	63.9
1995	15.3	20.1	28.7	34.2	42.7	51.2	55.8	60.0	64.7	68.0	
1996	15.4	21.6	28.8	38.3	41.8	45.9	55.4	60.1		76.0	
1997	16.2	20.9	27.8	35.2	40.3	47.5	50.6	55.4	63.2		
1998	14.5	22.9	29.3	36.8	43.5	48.2	51.7	54.1	58.5	70.0	65.0
1999	14.6	20.8	32.2	39.5	45.6	52.3	54.7	52.9	57.9	62.0	
2000	15.9	23.4	30.7	41.7	46.8	50.8	50.2	54.1	59.5	59.8	61.5
2001	14.6	22.3	32.2	37.6	47.4	51.4	58.3	53.6	65.8	67.6	67.5
2002	15.5	22.1	30.0	40.4	44.9	52.2	58.4	59.6	66.0	61.8	65.4
2003	16.4	23.8	28.0	37.2	46.6	49.9	55.2	59.8	57.6	61.4	69.8
2004	14.1	22.5	31.0	35.2	42.5	49.4	49.6	58.1	62.0	72.0	72.1
2005	14.6	21.8	29.9	36.7	41.2	48.1	51.7	57.6	60.0	67.0	

Table 4.11 Length at age data from the Norwegian bottom trawl survey smoothed by fitting a von Bertalanffy growth function to each of the yearclasses.

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	17.3	27.4	33.5	43.8	49.6	56.7	63.5	71.9	72.0	71.2	75.5
1981	15.2	28.7	36.7	41.0	50.3	55.1	61.4	67.3	74.6	74.5	73.5
1982	14.6	25.7	38.3	44.5	47.4	55.8	59.8	65.3	70.5	76.9	76.5
1983	14.2	24.7	34.5	46.3	51.0	52.9	60.5	63.8	68.5	73.1	78.6
1984	12.8	24.0	33.4	42.1	52.9	56.5	57.6	64.4	67.1	71.3	75.3
1985	13.5	21.9	32.5	40.8	48.6	58.4	61.2	61.6	67.8	70.0	73.6
1986	14.8	23.0	29.8	39.8	47.2	54.1	63.0	65.1	65.1	70.6	72.4
1987	15.7	25.0	31.2	36.8	46.1	52.7	58.8	66.8	68.4	68.0	72.9
1988	15.0	26.4	33.7	38.3	42.9	51.5	57.4	62.8	70.0	71.2	70.6
1989	14.4	25.3	35.5	41.2	44.5	48.2	56.2	61.4	66.2	72.7	73.5
1990	13.2	24.4	34.1	43.1	47.6	49.9	52.9	60.3	64.9	69.1	74.9
1991	12.4	22.5	32.9	41.6	49.6	53.1	54.6	56.9	63.8	67.9	71.6
1992	12.4	21.2	30.6	40.3	48.1	55.2	57.8	58.7	60.5	66.8	70.4
1993	12.8	21.2	28.9	37.6	46.7	53.6	59.8	61.8	62.2	63.7	69.4
1994	13.0	21.9	29.0	35.7	43.8	52.1	58.3	63.8	65.2	65.3	66.4
1995	13.7	22.2	29.8	35.8	41.7	49.1	56.8	62.3	67.2	68.2	68.0
1996	14.0	23.3	30.2	36.8	41.8	47.0	53.8	60.9	65.7	70.0	70.7
1997	14.0	23.7	31.6	37.2	42.9	47.1	51.6	57.9	64.4	68.6	72.4
1998	13.0	23.7	32.1	38.8	43.4	48.2	51.7	55.7	61.5	67.4	71.1
1999	13.7	22.1	32.1	39.4	45.0	48.7	52.9	55.8	59.3	64.6	69.9
2000	13.0	23.2	30.1	39.4	45.7	50.5	53.4	57.0	59.4	62.5	67.3
2001	12.4	22.1	31.5	37.1	45.6	51.1	55.2	57.5	60.5	62.6	65.3
2002	13.5	21.1	30.1	38.7	43.2	51.1	55.8	59.2	61.1	63.7	65.4
2003	13.4	22.9	28.8	37.1	44.9	48.6	55.8	59.9	62.8	64.2	66.4
2004	13.2	22.9	31.1	35.6	43.2	50.3	53.3	59.8	63.4	65.8	66.9
2005	14.6	22.4	31.0	38.2	41.6	48.6	55.0	57.3	63.4	66.4	68.5

Table 4.12 Weight at age data obtained from the Norwegian bottom trawl survey by fitting W=a*L^b and applying this relationship to the von Bertalanffy fitted length at age data.

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	0.061	0.229	0.409	0.875	1.251	1.835	2.537	3.610	3.625	3.516	4.166
1981	0.043	0.263	0.527	0.726	1.302	1.691	2.298	2.996	4.022	3.995	3.854
1982	0.038	0.190	0.598	0.915	1.098	1.754	2.134	2.741	3.414	4.374	4.317
1983	0.035	0.171	0.445	1.026	1.357	1.501	2.206	2.564	3.153	3.789	4.671
1984	0.026	0.157	0.404	0.784	1.504	1.820	1.915	2.642	2.970	3.530	4.120
1985	0.030	0.121	0.373	0.718	1.179	1.997	2.281	2.324	3.051	3.345	3.869
1986	0.039	0.138	0.292	0.666	1.087	1.602	2.480	2.723	2.716	3.427	3.686
1987	0.047	0.176	0.332	0.532	1.014	1.487	2.032	2.935	3.135	3.085	3.768
1988	0.041	0.206	0.415	0.598	0.824	1.396	1.899	2.452	3.352	3.512	3.426
1989	0.037	0.183	0.479	0.735	0.918	1.152	1.791	2.306	2.852	3.728	3.850
1990	0.029	0.164	0.430	0.839	1.110	1.274	1.501	2.186	2.697	3.225	4.061
1991	0.024	0.130	0.389	0.759	1.254	1.517	1.647	1.857	2.569	3.065	3.567
1992	0.024	0.110	0.314	0.693	1.145	1.695	1.933	2.023	2.211	2.932	3.406
1993	0.026	0.111	0.267	0.568	1.052	1.559	2.138	2.344	2.393	2.555	3.272
1994	0.028	0.121	0.270	0.489	0.876	1.443	1.983	2.569	2.737	2.747	2.883
1995	0.032	0.126	0.293	0.493	0.762	1.219	1.847	2.398	2.975	3.107	3.082
1996	0.034	0.144	0.304	0.533	0.768	1.072	1.581	2.248	2.795	3.350	3.448
1997	0.034	0.152	0.345	0.552	0.825	1.079	1.403	1.949	2.636	3.167	3.691
1998	0.027	0.151	0.361	0.620	0.853	1.153	1.412	1.745	2.312	3.002	3.508
1999	0.032	0.125	0.361	0.647	0.950	1.189	1.502	1.755	2.087	2.662	3.342
2000	0.027	0.143	0.301	0.646	0.987	1.314	1.545	1.859	2.098	2.422	2.994
2001	0.024	0.125	0.342	0.547	0.987	1.362	1.695	1.908	2.213	2.434	2.745
2002	0.030	0.109	0.301	0.615	0.845	1.361	1.751	2.077	2.267	2.557	2.757
2003	0.030	0.137	0.266	0.547	0.943	1.179	1.750	2.141	2.452	2.614	2.885
2004	0.028	0.137	0.329	0.487	0.845	1.305	1.533	2.140	2.520	2.810	2.945
2005	0.038	0.129	0.328	0.594	0.759	1.179	1.684	1.895	2.519	2.881	3.146

Table 4.13 Observed proportions mature at age from the Norwegian bottom trawl survey in February (both sexes).

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	0.00	0.00	0.00	0.03	0.09	0.38	1.00	1.00	1.00		
1981	0.00	0.05	0.02	0.05	0.39	0.70	1.00				
1982	0.00	0.00	0.02	0.02	0.33	0.69	0.95	1.00	1.00	1.00	1.00
1983	0.00	0.04	0.03	0.15	0.48	0.80	0.83		1.00	1.00	
1984	0.00	0.00	0.00	0.14	0.46	0.30	1.00	1.00		1.00	
1985	0.00	0.00	0.02	0.05	0.63	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.01	0.11	0.30	0.76	1.00	1.00			1.00	1.00
1987	0.00	0.08	0.12	0.16	0.85						1.00
1988	0.00	0.00	0.00	0.03	0.29	0.87	1.00		1.00		
1989	0.00	0.00	0.02	0.02	0.28	0.89	1.00			1.00	
1990	0.00	0.01	0.01	0.19	0.31	0.93	0.99	1.00		1.00	1.00
1991	0.00	0.00	0.08	0.17	0.30	0.41	0.80	1.00		0.98	
1992	0.00	0.00	0.02	0.14	0.51	0.77	0.77	1.00		0.97	1.00
1993	0.00	0.00	0.01	0.12	0.49	0.86	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.00	0.00	0.03	0.18	0.79	1.00	0.87	1.00	1.00	1.00
1995	0.00	0.00	0.00	0.02	0.18	0.56	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.00	0.01	0.07	0.13	0.31	0.88		1.00	1.00	1.00
1997	0.00	0.00	0.00	0.04	0.17	0.56	0.91	1.00	1.00	1.00	
1998	0.01	0.00	0.00	0.04	0.21	0.54	0.77	1.00	1.00	1.00	1.00
1999	0.00	0.00	0.00	0.04	0.24	0.65	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.00	0.00	0.24	0.55	0.90	1.00	1.00	1.00	1.00	1.00
2001	0.00	0.00	0.00	0.12	0.43	0.61	0.97	1.00	1.00	1.00	1.00
2002	0.00	0.00	0.01	0.09	0.26	0.67	0.90	1.00	1.00	0.95	1.00
2003	0.00	0.00	0.00	0.03	0.37	0.56	0.88	0.55	1.00	1.00	1.00
2004	0.00	0.00	0.00	0.02	0.21	0.92	1.00	1.00	1.00	1.00	1.00
2005	0.00	0.00	0.00	0.06	0.31	0.61	0.96	1.00		1.00	1.00

Table 4.14 Proportions mature at age from the Norwegian bottom trawl survey fitted using a logistic function with age and length as explanatory variables.

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	0.00	0.00	0.01	0.09	0.33	0.78	0.96	0.99	1.00	1.00	1.00
1981	0.00	0.00	0.02	0.10	0.43	0.77	0.96	0.99	1.00	1.00	1.00
1982	0.00	0.00	0.02	0.08	0.39	0.77	0.94	0.98	1.00	1.00	1.00
1983	0.00	0.00	0.02	0.13	0.44	0.80	0.95	0.99	1.00	1.00	1.00
1984	0.00	0.00	0.02	0.15	0.53	0.85	0.95	0.99	1.00	1.00	1.00
1985	0.00	0.00	0.02	0.10	0.55	0.85	0.95	0.99	1.00	1.00	1.00
1986	0.00	0.00	0.02	0.11	0.49	0.76	0.95	0.99	1.00	1.00	1.00
1987	0.00	0.00	0.01	0.07	0.34	0.73	0.93	0.99	1.00	1.00	1.00
1988	0.00	0.00	0.01	0.06	0.27	0.66	0.92	0.98	1.00	1.00	1.00
1989	0.00	0.00	0.02	0.07	0.27	0.62	0.90	0.98	1.00	1.00	1.00
1990	0.00	0.00	0.02	0.12	0.34	0.69	0.89	0.97	0.99	1.00	1.00
1991	0.00	0.00	0.02	0.13	0.38	0.72	0.91	0.97	0.99	1.00	1.00
1992	0.00	0.00	0.02	0.13	0.46	0.81	0.94	0.98	0.99	1.00	1.00
1993	0.00	0.00	0.02	0.11	0.41	0.78	0.93	0.99	0.99	1.00	1.00
1994	0.00	0.00	0.01	0.08	0.36	0.75	0.92	0.98	1.00	1.00	1.00
1995	0.00	0.00	0.01	0.06	0.28	0.70	0.91	0.98	1.00	1.00	1.00
1996	0.00	0.00	0.01	0.08	0.27	0.62	0.91	0.98	1.00	1.00	1.00
1997	0.00	0.00	0.01	0.07	0.25	0.64	0.88	0.97	0.99	1.00	1.00
1998	0.00	0.00	0.01	0.07	0.29	0.66	0.89	0.97	0.99	1.00	1.00
1999	0.00	0.00	0.02	0.09	0.33	0.72	0.91	0.97	0.99	1.00	1.00
2000	0.00	0.00	0.02	0.10	0.35	0.70	0.88	0.97	0.99	1.00	1.00
2001	0.00	0.00	0.02	0.08	0.36	0.71	0.93	0.97	1.00	1.00	1.00
2002	0.00	0.00	0.01	0.09	0.32	0.72	0.93	0.98	1.00	1.00	1.00
2003	0.00	0.00	0.01	0.08	0.34	0.68	0.91	0.98	0.99	1.00	1.00
2004	0.00	0.00	0.02	0.07	0.28	0.68	0.87	0.98	0.99	1.00	1.00

Table 4.15 NEA haddock mean length at age from the Russian bottom trawl survey in October-December (cm).

	Age										
YEAR	**0+(1)**	**1+(2)**	**2+(3)**	**3+(4)**	**4+(5)**	**5+(6)**	**6+(7)**	**7+(8)**	**8+(9)**	**9+(10)**	**10+(11)**
1982	14.5	21.3	33.4	37.0							
1983	18.1	26.2	30.9	44.9	53.3	62.0	65.5	67.6	68.0	73.1	81.0
1984		24.0	35.8	42.7	53.7	63.1	68.1	68.1	71.0	75.2	85.0
1985		21.1	31.7	43.4	53.6	62.2	64.2		73.1	74.1	72.4
1986	18.1	21.0	28.7	37.0	46.6	58.8	63.1	68.1		73.1	78.1
1987		21.7	27.6	33.3	40.9	49.4					
1988		19.9	29.9	35.1	40.4	46.6	52.0				
1989		20.5	25.1	40.2	45.0	48.5	52.2	58.8	63.5		88.1
1990		20.5	29.8	37.3	48.7	50.8	54.7	58.8	63.3	68.1	83.1
1991		23.2	31.7	40.3	52.7	56.7	58.8	60.3	63.2	69.1	73.7
1992		22.0	32.2	41.6	52.6	59.7	61.9	65.7	68.3	70.3	75.1
1993	18.1	20.8	28.0	38.6	48.8	55.0	61.2	64.1	63.2	65.0	70.3
1994	15.5	20.8	28.9	36.2	44.6	53.6	60.0	66.2	67.7	67.0	71.9
1995	14.9	21.8	28.6	36.6	42.0	48.3	56.6	62.5	66.1	66.8	71.9
1996	15.7	20.2	28.6	36.8	43.9	49.3	54.7	63.3	67.3	70.8	76.9
1997	13.7	23.3	29.5	36.6	44.6	50.0	54.7	58.7	69.1	68.1	69.7
1998	14.4	19.3	33.1	39.2	45.9	47.9	53.5	56.1	62.0	74.1	78.1
1999	13.5	22.6	28.0	41.9	46.6	49.2	53.1	56.3	59.8	63.5	69.5
2000	14.2	22.3	31.7	37.0	48.6	52.5	54.8	60.8	62.0	60.5	67.0
2001	14.8	21.9	30.7	40.3	45.1	53.0	57.3	60.7	62.2	62.5	67.8
2002	14.7	23.5	29.4	38.2	46.4	50.8	56.2	56.0	64.6	66.9	71.1
2003	13.8	22.7	29.4	37.5	43.9	50.5	55.2	61.1	63.3	63.5	70.4
2004	14.3	22.5	30.0	37.9	43.6	48.4	53.7	58.4	63.5	69.1	72.2

Table 4.16 NEA haddock mean weights at age from the Russian bottom trawl survey in October-December (g).

	Age										
YEAR	**0+(1)**	**1+(2)**	**2+(3)**	**3+(4)**	**4+(5)**	**5+(6)**	**6+(7)**	**7+(8)**	**8+(9)**	**9+(10)**	**10+(11)**
1982	32	102	364	500							
1983	57	170	271	916	1625	2346	2751	3153	3217	4290	5200
1984		124	434	722	1410	2296	3071	2942	3224	3747	5408
1985		94	302	788	1533	2275	2650		3400	4076	3943
1986	40	91	220	470	905	1759	2300	2500		3550	4100
1987		96	193	353	612	1101					
1988		84	250	409	641	1036	1451				
1989		94	160	718	926	1254	1548	2106	2781		7160
1990		97	264	530	1250	1474	1812	2188	2626	3080	5520
1991		122	342	702	1518	1915	2244	2324	2649	3249	3810
1992		103	310	726	1505	2101	2386	2977	3315	3773	4800
1993	55	84	197	543	1120	1568	2125	2474	2476	2803	3324
1994	34	91	217	435	850	1498	2167	2875	2880	2963	3742
1995	32	90	210	445	708	1123	1776	2398	2847	3032	3781
1996	37	80	210	468	854	1186	1643	2429	3038	2991	4413
1997	27	113	226	458	882	1191	1579	1963	3155	2815	3565
1998	38	72	340	593	972	1226	1593	1803	2389	3681	4494
1999	27	103	196	730	1003	1182	1522	1748	2148	2547	2807
2000	24	105	313	480	1197	1502	1713	2375	2445	2286	3065
2001	25	98	264	632	930	1534	1935	2383	2589	2631	3210
2002	26	127	302	586	1077	1470	2029	2127	1954	2933	3986
2003	21	103	229	498	797	1241	1649	2308	2617	3061	3390
2004	24	87	253	518	846	1130	1571	1959	2633	3366	3859

Table 4.17 NEA haddock length at age data from the Russian bottom trawl survey smoothed by fitting a von Bertalanffy growth function to each of the year classes (cm). Ages and years are shifted, as the data on the end of year are given for 1 January of the next year.

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	16.2	30.0	37.5	45.2	46.8	52.6	57.6	62.0	65.8	69.1	72.0
1981	16.1	27.9	40.4	45.8	52.2	52.6	57.6	62.0	65.8	69.1	72.0
1982	14.1	27.8	37.9	49.0	52.9	58.1	57.6	62.0	65.8	69.1	72.0
1983	13.3	24.6	37.7	46.2	56.2	58.8	63.2	62.0	65.8	69.1	72.0
1984	12.5	23.3	33.7	46.0	53.3	62.2	63.9	67.5	65.8	69.1	72.0
1985	12.4	22.0	32.0	41.5	53.1	59.3	67.1	68.1	71.1	69.1	72.0
1986	12.9	21.8	30.3	39.6	48.3	59.0	64.3	71.2	71.7	74.2	72.0
1987	14.1	22.7	30.2	37.7	46.2	54.1	64.0	68.5	74.6	74.8	76.8
1988	13.9	24.6	31.3	37.5	44.1	52.0	59.2	68.3	72.1	77.5	77.4
1989	14.0	24.3	33.7	38.8	43.9	49.8	57.1	63.6	71.9	75.1	79.9
1990	13.8	24.5	33.2	41.5	45.4	49.6	54.8	61.5	67.4	74.9	77.7
1991	12.3	24.1	33.5	41.0	48.3	51.1	54.6	59.2	65.3	70.6	77.5
1992	11.8	21.7	33.1	41.3	47.8	54.1	56.1	59.0	63.1	68.6	73.5
1993	12.1	20.8	30.0	40.8	48.1	53.6	59.2	60.5	62.9	66.5	71.6
1994	12.5	21.4	28.8	37.3	47.5	54.0	58.7	63.6	64.4	66.3	69.5
1995	12.6	21.9	29.5	35.9	43.7	53.4	59.0	63.1	67.4	67.8	69.3
1996	12.9	22.2	30.3	36.8	42.2	49.4	58.4	63.4	66.9	70.6	70.7
1997	13.5	22.6	30.6	37.6	43.1	47.8	54.3	62.8	67.2	70.2	73.5
1998	12.4	23.6	31.1	38.0	44.0	48.8	52.8	58.7	66.6	70.5	73.0
1999	13.0	21.8	32.4	38.6	44.5	49.7	53.8	57.2	62.6	69.9	73.3
2000	12.5	22.8	30.1	40.1	45.1	50.2	54.7	58.2	61.0	66.0	72.8
2001	12.4	22.0	31.3	37.4	46.8	50.8	55.2	59.1	62.0	64.5	69.1
2002	12.7	21.9	30.3	38.8	43.9	52.6	55.9	59.6	63.0	65.5	67.6
2003	12.8	22.4	30.2	37.6	45.4	49.6	57.6	60.3	63.5	66.4	68.5
2004	13.0	22.5	30.9	37.5	44.1	51.1	54.6	62.0	64.1	66.9	69.4
2005	14.1	22.7	31.0	38.3	43.9	49.8	56.2	59.0	65.8	67.5	69.9

Table 4.18 NEA haddock weight at age data obtained from the Russian bottom trawl survey and smoothed using W=a*L^b equation and applying this relationship to the von Bertalanffy fitted length at age data (g). Ages and years are shifted, as the data on the end of year are given for 1 January of the next year.

	Age										
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1980	38.5	257.6	512.0	908.1	1031.5	1471.5	1943.5	2428.4	2911.0	3379.7	3826.8
1981	37.8	206.9	643.1	949.2	1415.6	1471.5	1943.5	2428.4	2911.0	3379.7	3826.8
1982	25.1	203.1	527.0	1167.3	1473.8	1973.3	1943.5	2428.4	2911.0	3379.7	3826.8
1983	21.0	139.5	518.3	974.5	1777.1	2047.0	2549.6	2428.4	2911.0	3379.7	3826.8
1984	17.4	118.0	366.9	959.8	1509.5	2423.7	2635.8	3119.9	2911.0	3379.7	3826.8
1985	17.0	98.9	314.0	699.1	1488.8	2091.9	3068.8	3215.1	3666.6	3379.7	3826.8
1986	19.4	97.1	266.5	605.1	1113.7	2065.9	2688.1	3685.8	3767.5	4178.4	3826.8
1987	25.1	109.6	261.8	519.5	974.5	1584.3	2657.8	3272.7	4258.2	4281.9	4648.8
1988	24.1	139.6	293.3	510.9	845.6	1400.7	2086.3	3239.3	3828.2	4777.3	4752.2
1989	24.8	134.1	367.0	568.0	832.5	1227.7	1862.3	2598.4	3793.1	4343.9	5239.8
1990	23.6	137.6	353.6	699.2	918.9	1210.1	1648.1	2340.5	3104.3	4308.0	4813.9
1991	16.7	131.4	362.3	675.5	1113.9	1326.5	1626.1	2090.2	2820.0	3591.9	4778.3
1992	14.6	95.2	347.1	690.9	1079.0	1584.6	1770.8	2064.3	2540.1	3288.9	4052.9
1993	15.8	83.8	257.0	664.1	1101.6	1538.8	2086.5	2234.0	2510.8	2986.3	3738.6
1994	17.2	90.8	228.2	502.1	1062.1	1568.5	2031.1	2598.7	2701.4	2954.4	3420.2
1995	17.9	98.1	245.8	449.2	819.2	1516.6	2067.1	2535.2	3104.7	3161.2	3386.4
1996	19.0	101.8	264.5	481.7	738.2	1192.0	2004.1	2576.5	3035.0	3592.3	3604.8
1997	22.0	107.4	273.8	515.8	788.1	1081.7	1603.5	2504.3	3080.4	3518.5	4053.3
1998	17.0	123.3	287.8	532.7	840.0	1149.8	1464.6	2037.6	3001.0	3566.5	3977.1
1999	19.5	96.8	327.2	558.1	865.7	1220.1	1550.6	1872.8	2480.7	3482.3	4026.8
2000	17.3	110.1	261.2	628.8	903.9	1254.9	1638.6	1975.0	2293.5	2921.5	3939.7
2001	17.0	98.6	294.3	509.9	1009.8	1306.3	1681.9	2079.1	2409.7	2716.1	3351.5
2002	18.5	97.2	265.8	569.9	831.0	1447.5	1745.9	2130.0	2527.5	2843.9	3132.3
2003	18.8	104.7	262.0	518.1	921.7	1208.0	1919.7	2204.9	2584.8	2972.6	3269.0
2004	19.4	106.2	281.0	511.3	843.5	1330.1	1623.5	2407.0	2668.9	3035.0	3405.7
2005	25.1	109.9	284.8	545.8	833.2	1225.0	1775.3	2061.2	2893.7	3126.0	3471.8

Table 4.19 NEA haddock observed percent mature at age from the Russian bottom trawl survey in October-December (both sexes).

	Age												
YEAR	**1+(2)**	**2+(3)**	**3+(4)**	**4+(5)**	**5+(6)**	**6+(7)**	**7+(8)**	**8+(9)**	**9+(10)**	**10+(11)**	**11+(12)**	**12+(13)**	**13+(14)**
1983		20	23.3	37.8	75.4	78.0	84.6	93.7	80.7	100		100	96.9
1984	0	0.9	34.3	82.3	89.3	97.3	95.5	98.1	98.5	100			100
1985	0	0.1	17.2	45.5	84.1	69.8		100	34.7	28.3	27.2		
1986	0	0	4.7	45.2	53.1	100	55.3	0	100	100			0
1987	0	0	0	11.2	36.3	100				100		100	
1988	0	0	1.0	16.0	43.7	66.1						100	
1989	0	0.3	1.8	25.2	45.6	73.4	86.5	80				100	100
1990	0	0	1.8	32.0	59.6	86.3	91.9	100	100			100	100
1991	0	0	6.5	53.1	68.8	73.2	79.5	95.1	80	100			
1992	0	0.2	31.3	55.5	74.1	75.0	86.5	84.1	82.9	100		100	
1993	0	0	1.3	13.3	55.3	87.0	100	100	100	97.2	100	100	
1994	0	0	0.6	16.0	61.0	83.3	100	100	89.9	100	98.7	100	100
1995	0	0	0	15.0	47.7	81.4	87.2	100	91.9	86.8	100	100	100
1996	0	0	1.2	11.3	26.4	52.2	83.4	100	80	100	100	100	
1997	0	0	3.9	20.0	39.7	67.4	86.7	88.5	100	100	100	100	
1998	0	0	2.4	25.0	41.0	55.7	80.5	88.2	100	100		100	100
1999	0	0	5.7	32.6	57.3	72.6	85.6	94.2	93.0	100	100		100
2000	0	0.2	1.5	48.8	71.7	82.3	96.5	91.2	100	92.0	100	90.5	100
2001	0	0.3	5.7	29.6	71.9	78.9	82.4	92.1	100	90.5	75.4	100	100
2002	0	0.3	4.6	36.6	62.9	86.5	89.2	89.2	100	100	100	100	100
2003	0	0.2	3.6	17.6	55.5	81.9	94.5	97.8	93.5	88.0	98.8	100	99.6
2004	0	0.3	3.3	15.9	48.2	79.1	89.6	97.7	90.9	94.4	78.8	100	92.5

Table 4.20 NEA haddock percent mature at age from the Russian bottom trawl survey fitted using a logistic function with age and yearclass dependent age at 50% maturity as explanatory variables. Ages and years are shifted, as the data on the end of year are given for 1 January of the next year.

	Age												
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1980	0	0	1.2	7.4	31.9	57.7	78.5	87.1	89.5	93.0	96.1	95.6	100
1981	0	0	1.2	7.4	31.9	57.7	78.5	87.1	89.5	93.0	96.1	95.6	100
1982	0	0	1.2	7.4	31.9	57.7	78.5	87.1	89.5	93.0	96.1	95.6	100
1983	0	0	1.2	7.4	31.9	57.7	78.5	87.1	89.5	93.0	96.1	95.6	100
1984	0	0	5.9	37.8	48.1	75.4	78.0	85.6	93.8	93.0	96.1	95.6	100
1985	0	0	2.4	17.2	66.9	75.5	91.1	92.2	95.2	98.1	96.1	95.6	100
1986	0	0	1.9	7.5	41.0	87.1	91.1	97.1	97.5	98.5	99.4	95.6	100
1987	0	0	2.2	6.1	21.2	69.8	95.7	97.2	99.1	99.2	99.5	99.8	100
1988	0	0	2.9	7.0	17.8	47.2	88.5	98.7	99.1	99.7	99.8	99.9	100
1989	0	0	4.0	9.0	20.1	41.9	74.8	96.2	99.6	99.7	99.9	99.9	100
1990	0	0	6.3	12.1	24.7	45.5	70.6	90.8	98.8	99.9	99.9	100.0	100
1991	0	0	5.0	18.4	31.3	52.1	73.6	88.9	97.1	99.6	100.0	100.0	100
1992	0	0	3.2	14.8	42.8	60.3	78.4	90.2	96.4	99.1	99.9	100.0	100
1993	0	0	1.4	10.1	36.6	71.3	83.5	92.3	96.9	98.9	99.7	100.0	100
1994	0	0	1.3	4.6	27.1	65.8	89.2	94.4	97.6	99.0	99.7	99.9	100
1995	0	0	1.3	4.1	13.8	55.3	86.5	96.5	98.2	99.3	99.7	99.9	100
1996	0	0	2.0	4.1	12.4	34.8	80.5	95.5	98.9	99.5	99.8	99.9	100
1997	0	0	3.0	6.4	12.5	32.0	64.0	93.2	98.6	99.7	99.8	99.9	100
1998	0	0	4.2	9.4	18.6	32.3	61.0	85.5	97.9	99.6	99.9	100.0	100
1999	0	0	5.9	12.7	25.7	43.2	61.4	83.9	95.2	99.3	99.9	100.0	100
2000	0	0	3.6	17.3	32.7	53.5	71.7	84.1	94.5	98.5	99.8	100.0	100
2001	0	0	3.6	11.0	41.1	61.8	79.3	89.4	94.6	98.3	99.5	99.9	100
2002	0	0	2.2	10.9	29.2	69.9	84.3	92.7	96.6	98.3	99.5	99.9	100
2003	0	0	0.3	7.1	29.0	57.8	88.5	94.7	97.7	98.9	99.5	99.8	100
2004	0	0	0.2	3.6	20.2	57.6	82.0	96.3	98.3	99.3	99.7	99.8	100
2005	0	0	0.3	3.3	15.9	45.7	81.9	93.8	98.8	99.5	99.8	99.9	100

Table 4.21 Combined mean weight at age in the stock.

	Age										
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1950	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1951	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1952	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1953	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1954	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1955	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1956	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1957	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1958	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1959	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1960	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1961	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1962	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1963	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1964	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1965	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1966	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1967	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1968	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1969	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1970	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1971	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1972	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1973	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1974	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1975	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1976	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1977	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1978	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1979	0.03	0.14	0.35	0.66	1.04	1.47	1.93	2.42	2.88	3.32	3.73
1980	0.05	0.24	0.46	0.89	1.14	1.65	2.24	3.02	3.27	3.45	4.00
1981	0.04	0.23	0.59	0.84	1.36	1.58	2.12	2.71	3.47	3.69	3.84
1982	0.03	0.20	0.56	1.04	1.29	1.86	2.04	2.58	3.16	3.88	4.07
1983	0.03	0.16	0.48	1.00	1.57	1.77	2.38	2.50	3.03	3.58	4.25
1984	0.02	0.14	0.39	0.87	1.51	2.12	2.28	2.88	2.94	3.45	3.97
1985	0.02	0.11	0.34	0.71	1.33	2.04	2.67	2.77	3.36	3.36	3.85
1986	0.03	0.12	0.28	0.64	1.10	1.83	2.58	3.20	3.24	3.80	3.76
1987	0.04	0.14	0.30	0.53	0.99	1.54	2.34	3.10	3.70	3.68	4.21
1988	0.03	0.17	0.35	0.55	0.83	1.40	1.99	2.85	3.59	4.14	4.09
1989	0.03	0.16	0.42	0.65	0.88	1.19	1.83	2.45	3.32	4.04	4.55
1990	0.03	0.15	0.39	0.77	1.01	1.24	1.57	2.26	2.90	3.77	4.44
1991	0.02	0.13	0.38	0.72	1.18	1.42	1.64	1.97	2.69	3.33	4.17
1992	0.02	0.10	0.33	0.69	1.11	1.64	1.85	2.04	2.38	3.11	3.73
1993	0.02	0.10	0.26	0.62	1.08	1.55	2.11	2.29	2.45	2.77	3.51
1994	0.02	0.11	0.25	0.50	0.97	1.51	2.01	2.58	2.72	2.85	3.15
1995	0.02	0.11	0.27	0.47	0.79	1.37	1.96	2.47	3.04	3.13	3.23
1996	0.03	0.12	0.28	0.51	0.75	1.13	1.79	2.41	2.92	3.47	3.53
1997	0.03	0.13	0.31	0.53	0.81	1.08	1.50	2.23	2.86	3.34	3.87

Table 4.21 Continued.

1998	0.02	0.14	0.32	0.58	0.85	1.15	1.44	1.89	2.66	3.28	3.74
1999	0.03	0.11	0.34	0.60	0.91	1.20	1.53	1.81	2.28	3.07	3.68
2000	0.02	0.13	0.28	0.64	0.95	1.28	1.59	1.92	2.20	2.67	3.47
2001	0.02	0.11	0.32	0.53	1.00	1.33	1.69	1.99	2.31	2.58	3.05
2002	0.02	0.10	0.28	0.59	0.84	1.40	1.75	2.10	2.40	2.70	2.94
2003	0.02	0.12	0.26	0.53	0.93	1.19	1.83	2.17	2.52	2.79	3.08
2004	0.02	0.12	0.31	0.50	0.84	1.32	1.58	2.27	2.59	2.92	3.18
2005	0.03	0.12	0.31	0.57	0.80	1.20	1.73	1.98	2.71	3.00	3.31

Table 4.22 Combined maturity at age data.

	Age								
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1950	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1951	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1952	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1953	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1954	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1955	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1956	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1957	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1958	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1959	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1960	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1961	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1962	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1963	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1964	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1965	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1966	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1967	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1968	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1969	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1970	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1971	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1972	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1973	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1974	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1975	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1976	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1977	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1978	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1979	0.01	0.10	0.32	0.64	0.85	0.95	0.98	0.99	1.00
1980	0.01	0.10	0.36	0.67	0.85	0.93	0.97	0.97	1.00
1981	0.01	0.09	0.36	0.66	0.85	0.93	0.97	0.97	1.00
1982	0.01	0.10	0.34	0.67	0.85	0.93	0.97	0.97	1.00
1983	0.01	0.11	0.37	0.65	0.85	0.93	0.97	0.97	1.00
1984	0.01	0.24	0.47	0.77	0.85	0.92	0.97	0.97	1.00
1985	0.01	0.13	0.52	0.78	0.93	0.95	0.97	0.99	1.00
1986	0.01	0.08	0.38	0.81	0.93	0.98	0.99	0.99	1.00
1987	0.01	0.07	0.27	0.71	0.94	0.98	0.99	1.00	1.00
1988	0.01	0.08	0.23	0.59	0.90	0.98	0.99	1.00	1.00
1989	0.01	0.09	0.26	0.54	0.83	0.97	1.00	1.00	1.00
1990	0.01	0.12	0.30	0.57	0.80	0.94	0.99	1.00	1.00
1991	0.01	0.14	0.35	0.63	0.82	0.93	0.98	1.00	1.00
1992	0.01	0.12	0.40	0.68	0.85	0.94	0.98	0.99	1.00
1993	0.01	0.09	0.36	0.73	0.89	0.95	0.98	0.99	1.00
1994	0.01	0.06	0.28	0.69	0.91	0.96	0.99	0.99	1.00
1995	0.01	0.05	0.20	0.61	0.89	0.97	0.99	1.00	1.00
1996	0.01	0.06	0.20	0.49	0.85	0.97	0.99	1.00	1.00
1997	0.01	0.07	0.21	0.48	0.76	0.95	0.99	1.00	1.00

Table 4.22 Continued.

1998	0.01	0.09	0.24	0.49	0.75	0.91	0.99	1.00	1.00
1999	0.01	0.11	0.29	0.55	0.76	0.91	0.97	1.00	1.00
2000	0.01	0.13	0.33	0.61	0.81	0.91	0.97	0.99	1.00
2001	0.01	0.09	0.37	0.66	0.85	0.93	0.97	0.99	1.00
2002	0.01	0.10	0.29	0.70	0.88	0.95	0.98	0.99	1.00
2003	0.01	0.07	0.30	0.62	0.90	0.96	0.99	0.99	1.00
2004	0.01	0.05	0.25	0.63	0.86	0.97	0.99	1.00	1.00
2005	0.01	0.06	0.21	0.56	0.86	0.96	0.99	1.00	1.00

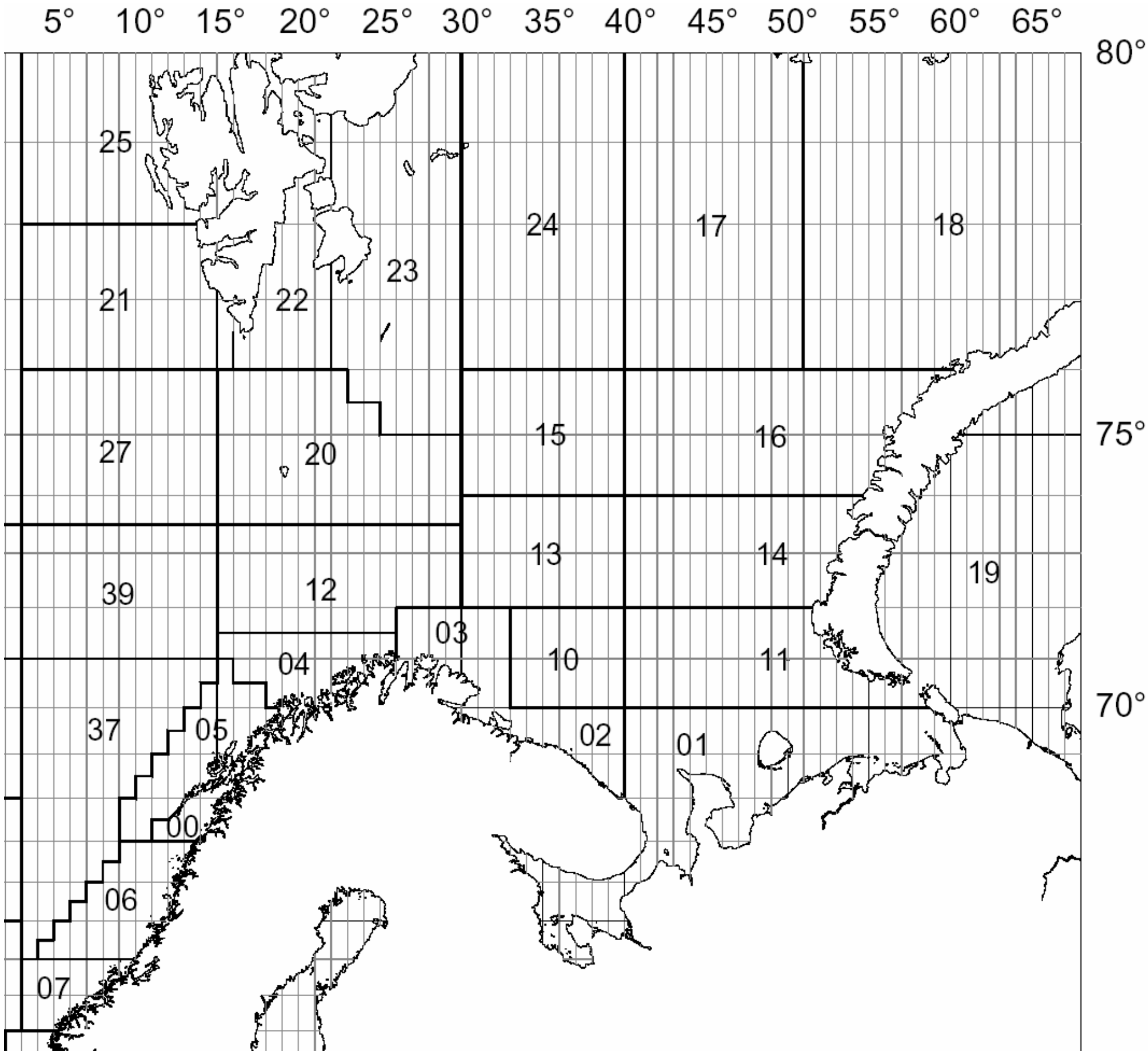


Figure 4.1 Norwegian statistical areas

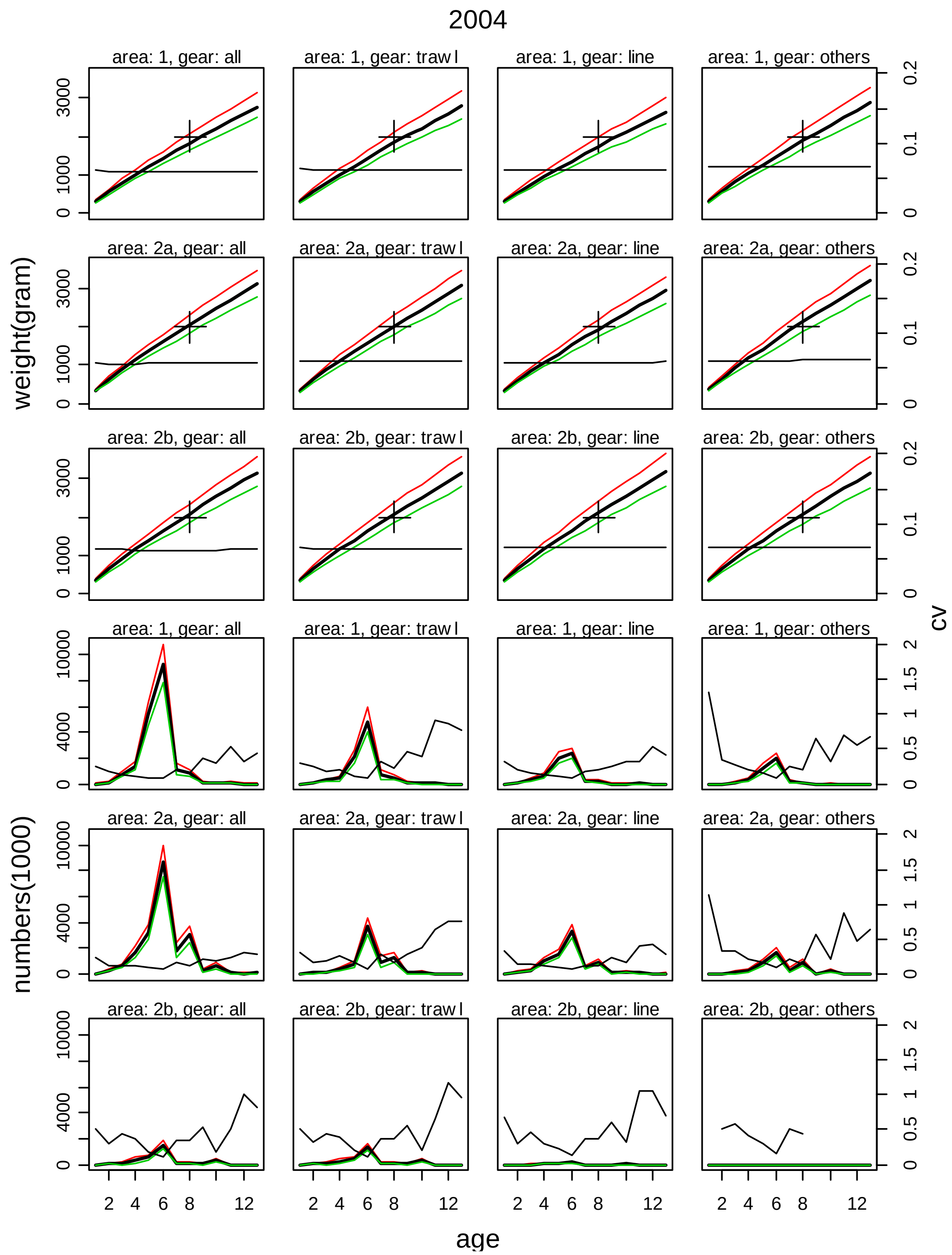


Figure 4.2 Norwegian catch at age and weight at age for 2004 by gear and ICES area (thick lines), with 95% confidence intervals and CVs (thin black lines).

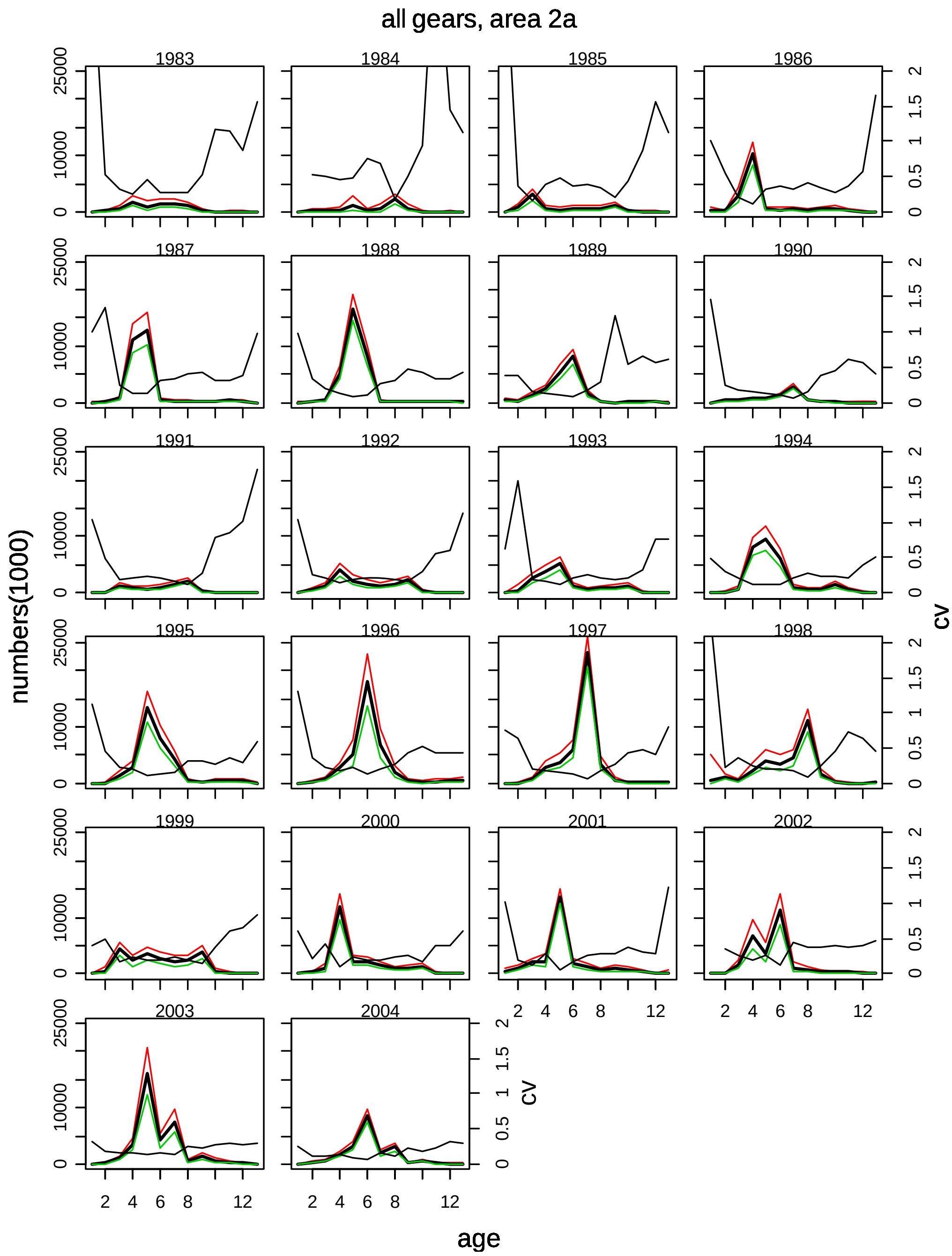


Figure 4.3 Total Norwegian catch at age in area IIa (thick lines), with 95% confidence intervals and CV (thin black lines), for the period 1983–2004.

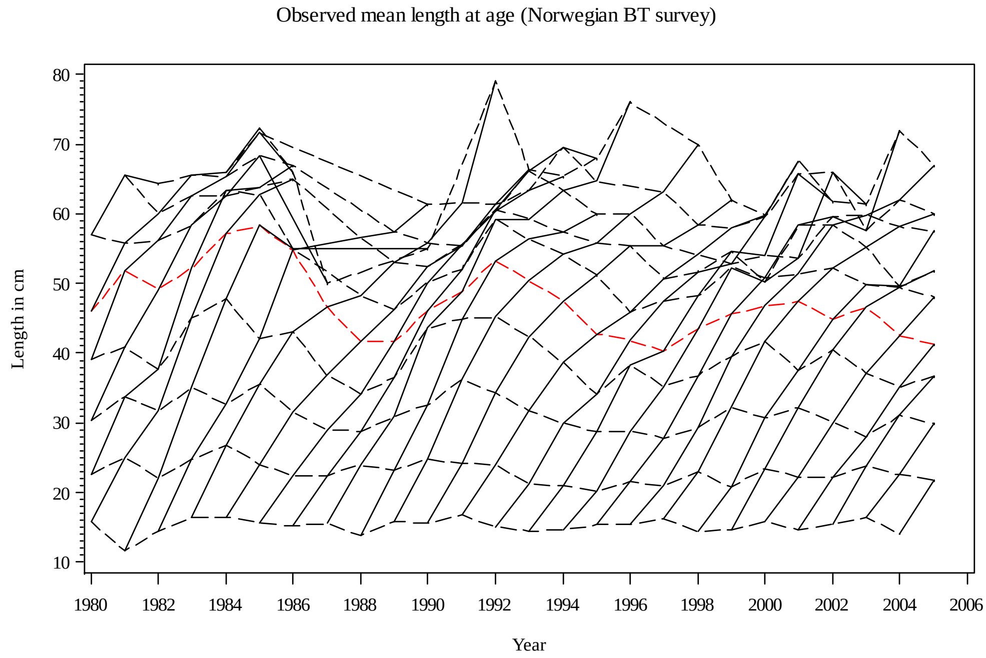


Figure 4.4 Mean length at age from the Norwegian bottom trawl survey in February. Solid lines connect the year class, while the dotted lines show length at ages 1 to 10. Red line corresponds to age 5.

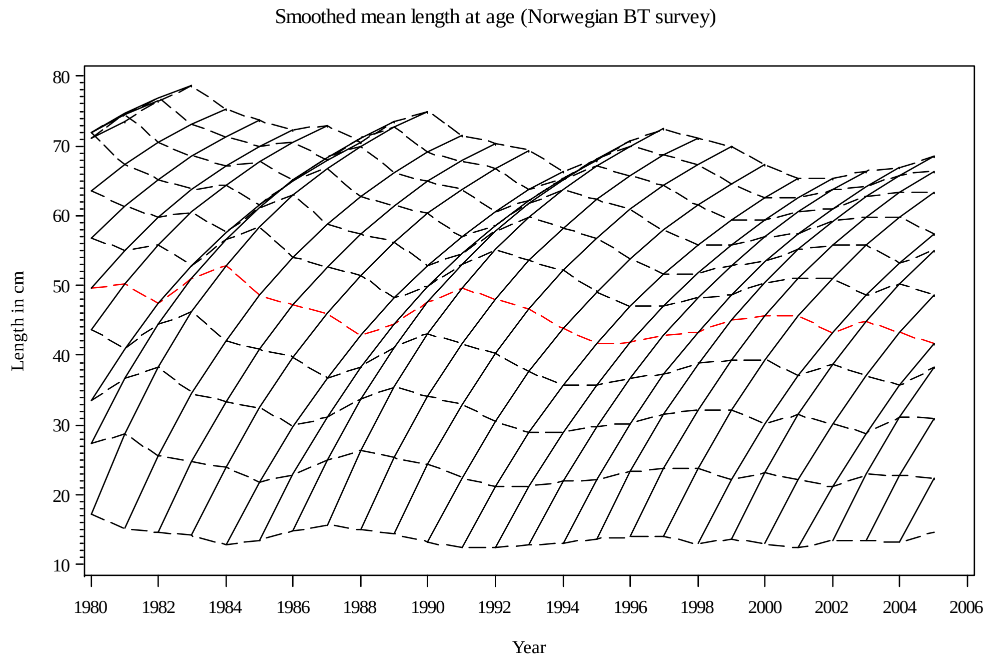


Figure 4.5 Length at age data from the Norwegian bottom trawl survey smoothed by fitting a von Bertalanffy growth function to each of the yearclasses. Red line corresponds to age 5.

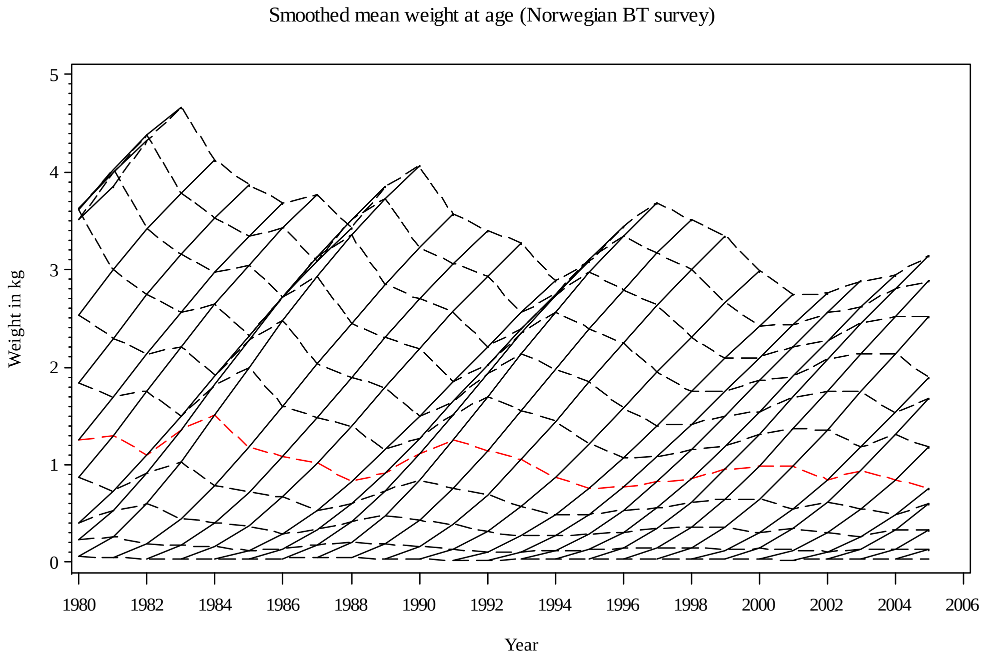


Figure 4.6 Weight at age data obtained from the Norwegian bottom trawl survey by fitting W=a*L^b and applying this relationship to the von Bertalanffy fitted length at age data. Red line corresponds to age 5.

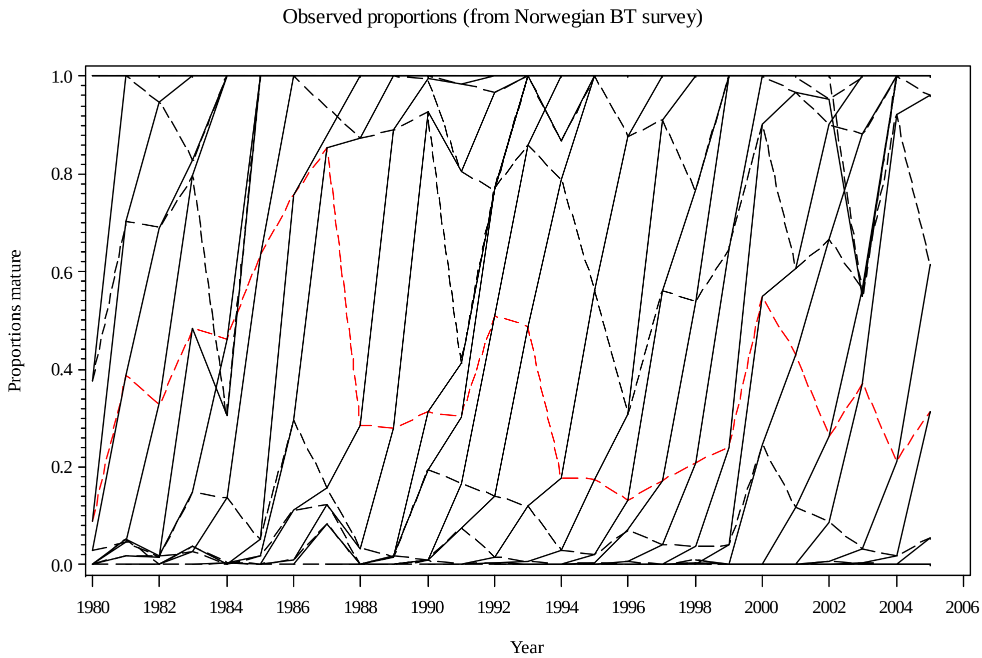


Figure 4.7 Observed proportions mature from the Norwegian bottom trawl survey in February. Solid lines connect year classes, while dotted lines represents proportions mature at age (both sexes). Red line corresponds to age 5.

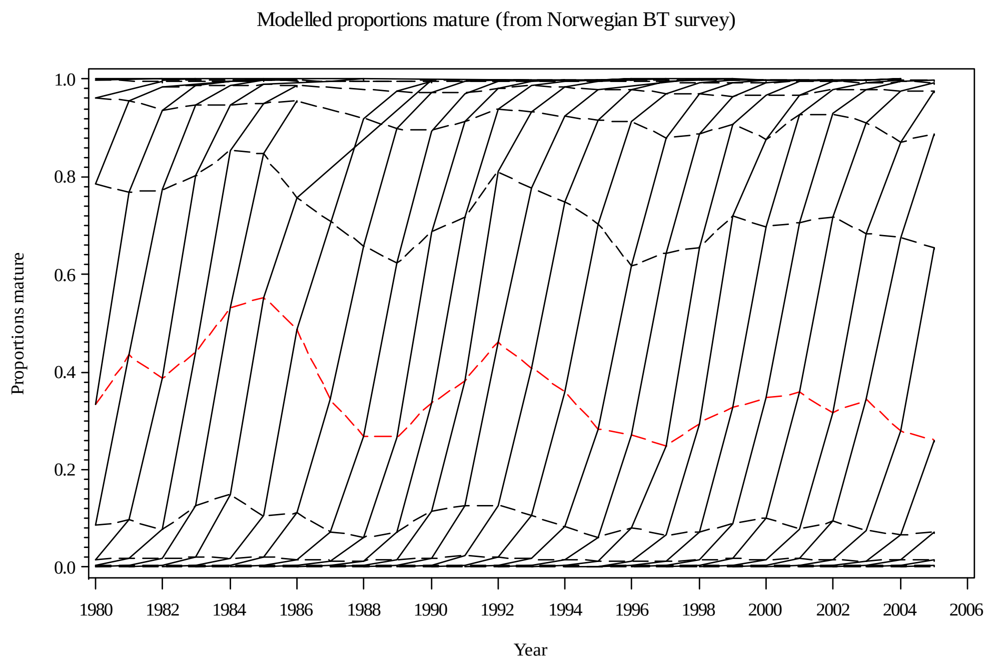


Figure 4.8 Proportions mature at age from the Norwegian bottom trawl survey fitted using a logistic function with age and length as explanatory variables. Red line corresponds to age 5.

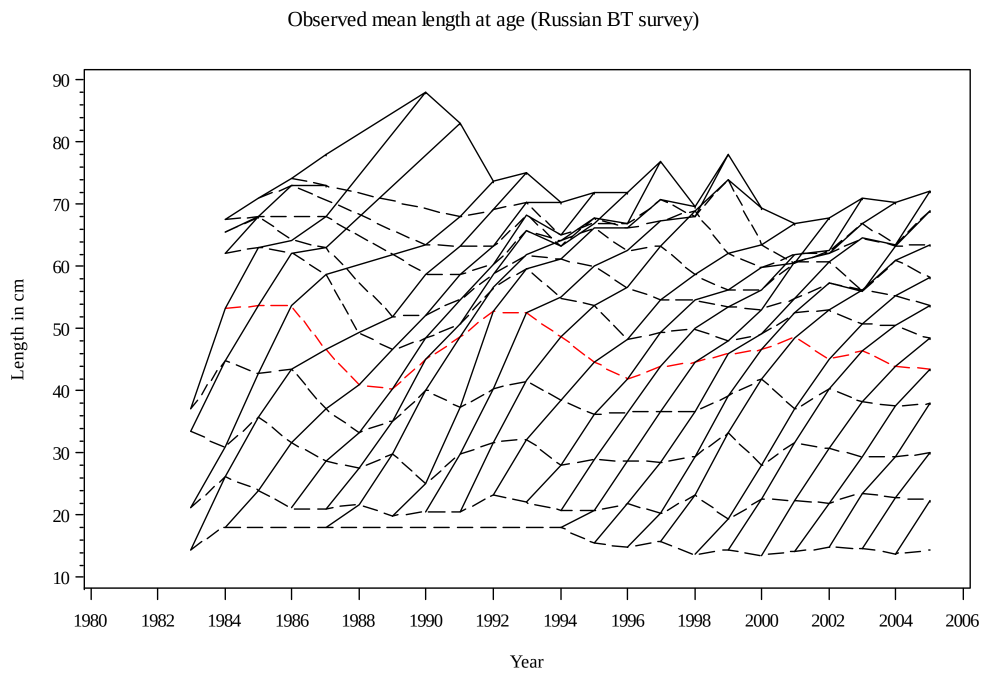


Figure 4.9 NEA haddock mean length at age from the Russian bottom trawl survey in October-December. Solid lines connect the year class, while the dotted lines show length at ages 1 to 11. Red line corresponds to age 5.

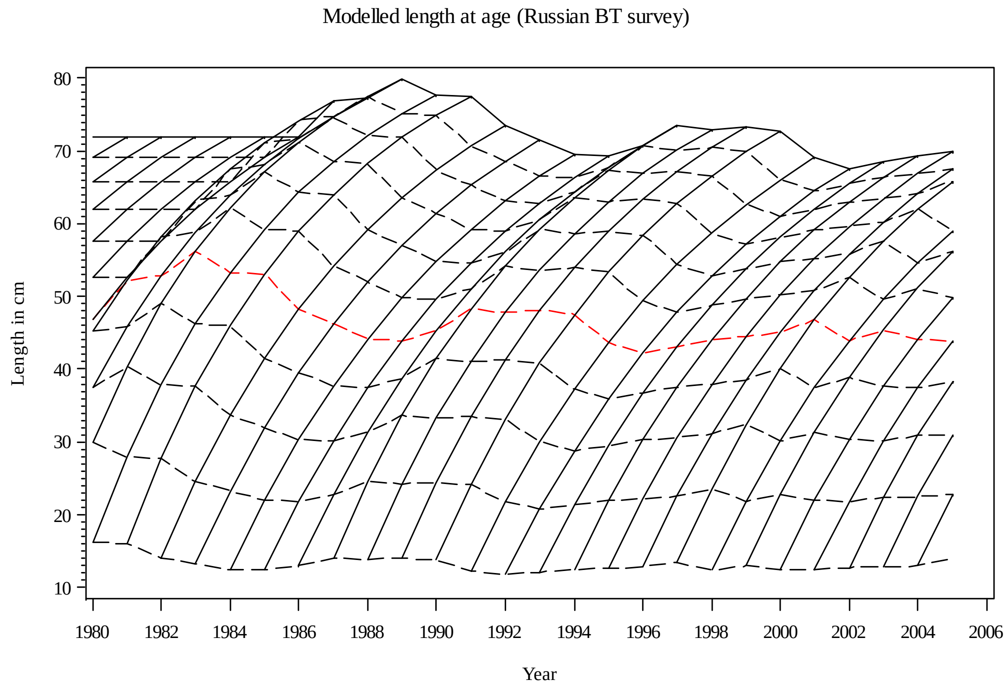


Figure 4.10 NEA haddock length at age data from the Russian bottom trawl survey smoothed by fitting a von Bertalanffy growth function to each of the year classes. Solid lines connect the year class, while the dotted lines show length at ages 1 to 11. Red line corresponds to age 5.

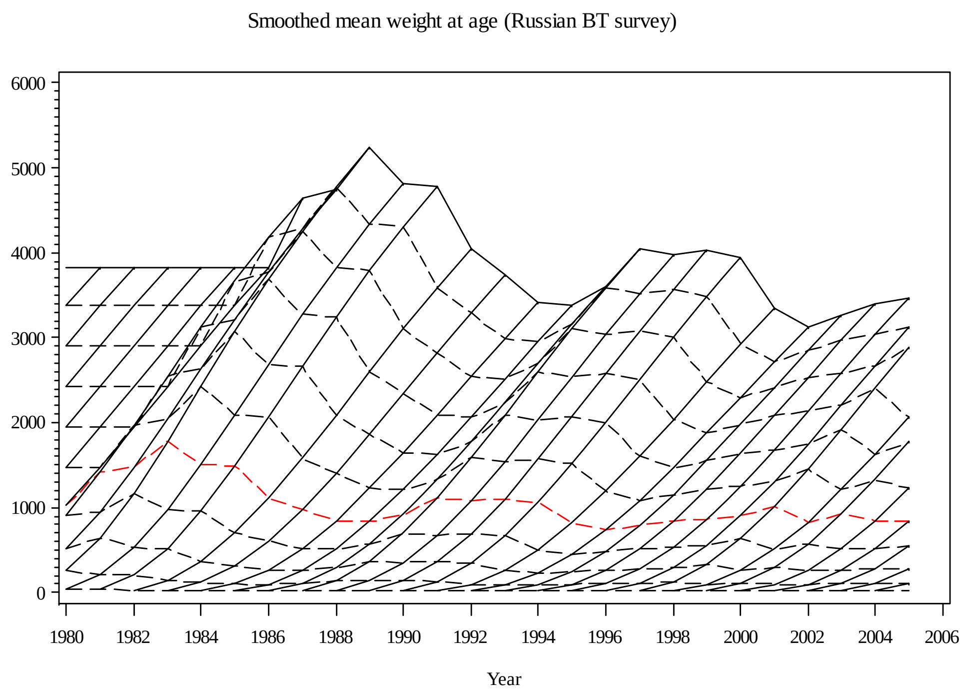


Figure 4.11 NEA haddock weight at age data obtained from the Russian bottom trawl survey by fitting W=a*L^b and applying this relationship to the von Bertalanffy fitted length at age data. (vertical axis label should have been “Weight in g”). Red line corresponds to age 5.

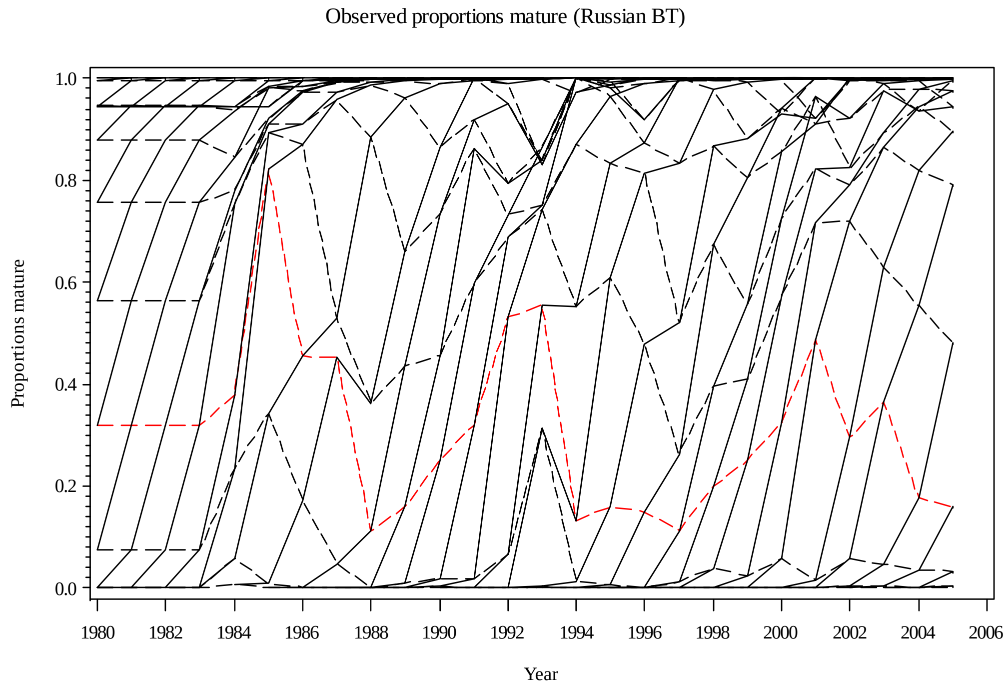


Figure 4.12 NEA haddock observed proportions of mature from the Russian bottom trawl survey. Solid lines connect year classes, while dotted lines represents proportions mature at age (both sexes). Red line corresponds to age 5. Red line corresponds to age 5.

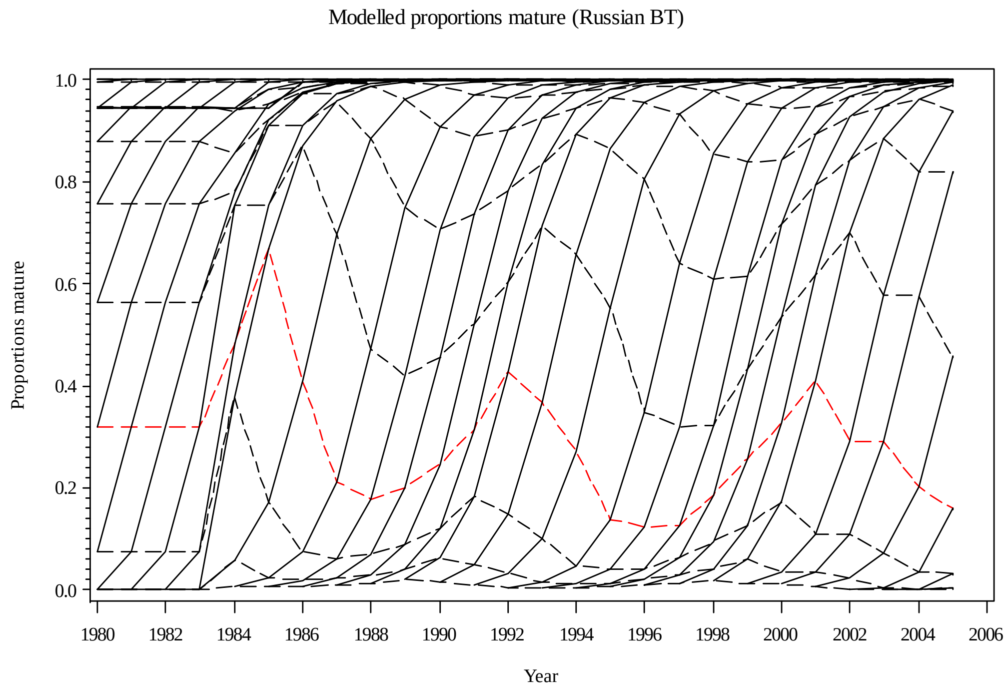


Figure 4.13 NEA haddock proportions of mature at age from the Russian bottom trawl survey fitted using a logistic function with age and year class dependent *age at 50%* maturity as explanatory variables. Red line corresponds to age 5. Red line corresponds to age 5.

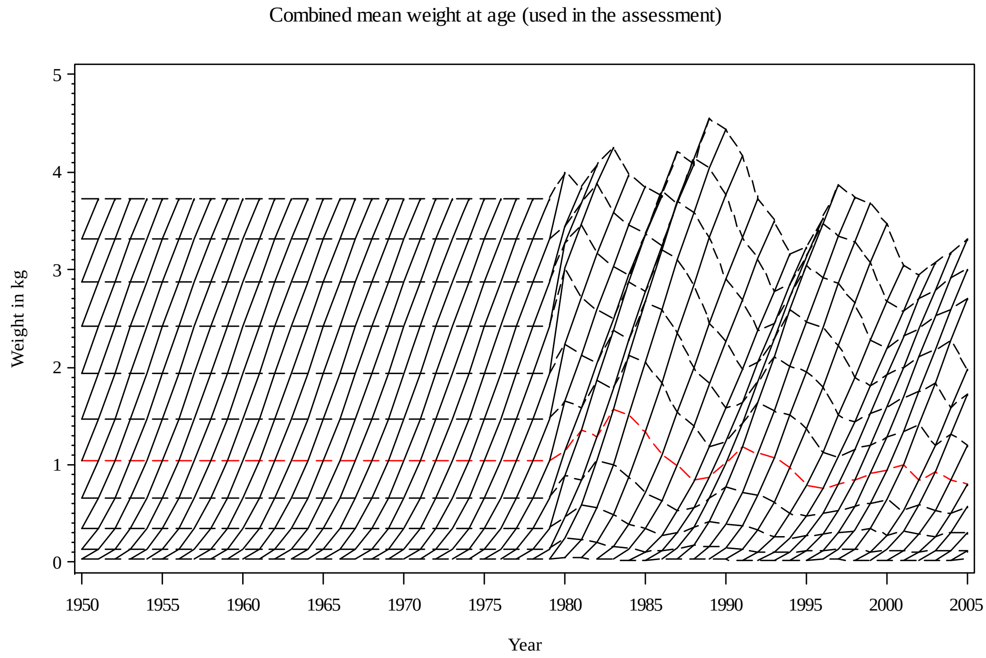


Figure 4.14 Mean weight at age in the stock combined from Norwegian and Russian mean weight at age data. Red line corresponds to age 5.

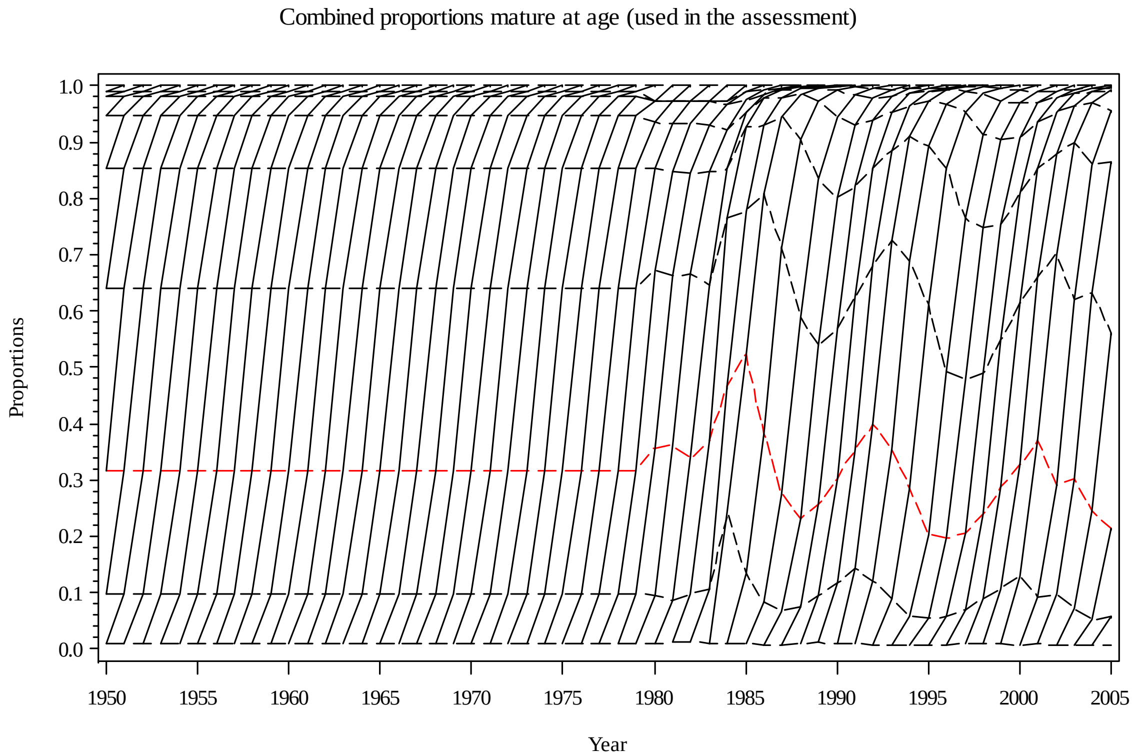


Figure 4.15 Maturity at age. Data combined from Norwegian and Russian maturity at age data. Red line corresponds to age 5.

5 Stock dynamics

5.1 Estimation of stock dynamics (XSA)

5.1.1 Landings prior to 2005

Landings from 1983 to 2003 were changed due to information of Norwegian landings in coastal regions of Norwegian economical zone and increased to compare with previous data for this period. Reported landings in 2003–2004 are still provisional. They now amount to 105 700 t in 2003 and 124 502 t in 2004, which is less than the agreed TAC for 2004 (130 000 t).

5.1.2 Data Used in the Assessment

Catch-at-age

See Table 4.8.

Weight-at-age in the catch

See Table 4.9. Revised weights in the catch at age 3 and 4 for both periods (with average data from 1950 to 1979 and with observed data for each year from 1980 to 2004) were lower than those used in assessment in 2005 and in previous years. The weights-at-age in the catch for older fish are showing with rare exception a decreasing trend for 1980–2004 in comparison with data used in input files before the revision. The weights-at-age in the catch in 2004 are showing an inclining tendency for most ages, but for ages 3-5 they still lower than in 1998–2002.

Stock weights (See Table 4.21) used from 1980 to 2004 are averages of values derived from Russian surveys in autumn (mostly October-December) and Norwegian surveys in January-March the following year. These averages are assumed to give representative values for the beginning of the year. Revised average weights-at-age in the stock in 1950–1979 in assessment as average of new data values derived for the period from 1980 to 2004 were reduced for all ages relative to the 2005 assessment. In 1980–2004 for which an individual data for each year have been used weights in the stock at age 4 and especially 3 were higher than those used in previous assessments.

Natural mortality

Natural mortality was set to 0.2+mortality from predation by cod. The only change done in the input file was replacing the 0.2 for all age groups previous to 1984 with the average natural mortality for 1984–2004 (Age groups 1–6).

Maturity-at-age

Maturity ogives were available from Russia and Norway for the period 1980–2004. The ogives for 2001–2004 shows a relatively early maturation compared to the second part of 1990’s, while the ogives for ages 3–4 in 2004 indicates slight reduction in the proportions mature relative to the preceding years. The maturity-at-age series for the whole period 1950–2004 is shown in Table 4.22. Using modelled/smoothed ogives has removed sudden “jumps” in the historic SSB estimates.

Tuning data

No changes have been made in data used for tuning (See ICES, 2005). The same surveys series are included in the data for tuning. The indices for the Russian BT survey in the 1990 and indices for 1996-year class were not used for tuning the XSA.

5.1.3 The XSA assessment

The Extended Survivors Analysis (XSA) was used to tune the VPA to the available index series, the settings used by the AFWG in 2005 were not changed (See ICES, 2005)

The matrix of natural mortality coefficients was used in the final XSA instead of using the number of haddock consumed by cod (see Table 5.3).

The tuning diagnostics of the final XSA (predation included) are given in Table 5.4.

As in the last year assessment the convergence of XSA did not occur at ages older than 5 years after 30 iterations. With increased number of iterations the total absolute differences in F between iterations became greater.

Fishing mortalities is given in Table 5.5, the stock numbers of the final VPA - in Table 5.6, the stock biomass at age – in Table 5.7, the spawning stock biomass at age is given in Tables 5.8, summary data – in Table 5.9.

This assessment showed the fishing mortality for the period from 2000 to 2004 to be much lower compared to the second half of 1990's.

The majority of the reported 2004 catches consisted of the 1998, 1999 and 2000 year classes. Compared to the 2003 catches the 1998 year class contribution decreased and the 1999 and 2000 year classes increased.

The largest contribution (more than 40 %) to the spawning stock in 2004 was made by the 1998 year class while about the 50 % was provided by 1996, 1997 and 1999 cohorts.

5.1.4 Comparing the revised assessment with the WG assessment

Nearly all revised fishing mortalities for the period from 1980 to 2004 are lower compared to the 2005 WG assessment. F4-7 indicated slightly reduced fishing mortality in 1950–1980 and quite essential decreasing for the later years, especially in the first half of 80th and in last 10 years.

An increased revised maturity ogives (both average for 1950–1979 and individual for 1980–2004) and using natural mortality data (average for 1950–1983) caused a substantial growth of spawning stock number for the whole period with minor excluding for some years (Figure 5.3) while decreased average weights-at-age resulted in keeping the spawning stock biomass in 1950–1980 on the same level in comparison with previous assessments. By the same reason similar trends were observed for total abundance and biomass dynamics.

The new assessment showed increasing recruitment of all year classes at age 3 for the whole time series with the only exception of the 1983 year class. The growth of abundance have been caused mainly by using the average natural mortality data for the years prior to 1983 never used before and due to new number and matrix of catches for the period after 1983.

Due to revised data for natural mortality caused by predation of cod the recruitment indices increased, especially for abundant year classes (Figure 5.4) to compare with 2005 assessment.

5.2 Estimation of stock dynamics (FLXSA approach)

5.2.1 FLR

FLR (Fish Lab in R) is a generic software framework intended to be used to evaluate and develop management strategies for a broad range of objectives. The framework uses R, an open-source statistical environment. In order to develop advice that is robust to uncertainties in our knowledge about the dynamics of fishery systems, their response to management and our ability to monitor, assess and control them, the framework must explicitly include a variety of processes. Currently the framework is being used to develop bio-economic models, multi-annual management plans and fishery independent assessment methods within a variety of EU Projects. Further information can be found at: http://www.flr-project.org/doku.php.

FLXSA is a package in the FLR framework, which performs a standard ICES XSA.

5.2.2 Data and settings

The data used in the assessment were the same as described in Section 5.1. In the FLR framework SOP corrections of the catch data was not an option. This option is used in standard XSA due to the older part of the haddock time series. The FLXSA control settings are shown in Table 5.10 and are otherwise the same as the regular analysis (see Section 5.1). It should be noted that although “window” was set to 15, it turned out that the whole time span with index data was used in the tuning. This means that the survey data from 1983–1989 was used in this run while not in the standard ICES XSA. Fbar is set to 4-7 as in standard assessments.

5.2.3 Results

The results of the FLXSA can be seen in Table 5.11 and time series plots can be seen in Figure 5.5. The estimates of the recruitment and fishing mortality rates are the same as in the standard XSA run from the above section (see Table 5.9, 5.5). There are only insignificant differences. The spawning stock biomass is the same as the XSA without SOP corrections (Table 5.9). It differs somewhat when SOP corrections are included (Table 5.8). They look more or less the same, but with small differences. The estimates of total biomass are different, likely due to differences in age range.

Residuals and diagnostics from the analysis can be seen in Table 5.12. Comparing some of the diagnostics was somewhat confusing, and the working group assumes that “Slope” in FLXSA is the same as “Intercept” in ICES XSA and that “power” in FLXSA is the same as “Slope” in ICES XSA. Comparing the numbers this way gives numbers in the same range. If our assumption is correct, the differences may be due to different tuning windows. For the Russian survey they are about the same, while the differences are somewhat greater for the Norwegian surveys, especially for the younger age groups. The log catchabilities vary somewhat between the two runs. This is expected due to the different tuning windows. However the log mean catchabilities are the same in the results from the two XSA versions and for all 3 surveys. (Please note that in the FLR diagnostics they are given as mean q, while log mean q in the ICES XSA diagnostics.) In contrast to the ICES XSA run, there are no residuals for the Norwegian Acoustic survey from 1990. The workshop did not have time available to sort out this problem.

Biological reference points have not been calculated. A retrospective XSA has been carried out and the results are shown in Figure 5.12.

Table 5.1 Catch numbers at age (Numbers, thousands spec)

Run title : NEA Haddock (SVPA AKHAD06)

At 8/03/2006 17:49

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1950	1951	1952	1953	1954
AGE					
3	3189	65643	6012	64528	6563
4	37949	9178	151996	13013	154696
5	35344	18014	13634	70781	5885
6	18849	13551	9850	5431	27590
7	28868	6808	4693	2867	3233
8	9199	6850	3237	1080	1302
9	1979	3322	2434	424	712
10	1093	1182	606	315	319
+gp	2977	1348	880	1005	543
0 TOTALNUM	139447	125896	193342	159444	200843
TONSLAND	132125	120077	127660	123920	156788
SOPCOF %	61	79	56	68	66

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	1154	16437	2074	1727	20318	39910	15429	39503	28466	22363
4	10689	5922	24704	5914	7826	70912	56855	30868	72736	49290
5	176678	14713	7942	31438	7243	13647	63351	48903	18969	30672
6	4993	127879	12535	5820	14040	7101	8706	33836	13579	5815
7	28273	3182	46619	12748	3154	6236	3578	3201	9257	3527
8	1445	8003	1087	17565	2237	1579	4407	1341	1239	2716
9	271	450	1971	822	5918	2340	788	1773	559	833
10	100	200	356	1072	285	2005	527	242	409	104
+gp	100	185	176	601	500	606	1434	756	375	633
0 TOTALNUM	223703	176971	97464	77707	61521	144336	155075	160423	145589	115953
TONSLAND	202286	213924	123583	112672	88211	154651	193224	187408	146224	99158
SOPCOF %	63	77	78	87	103	93	98	92	85	72

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	5936	26345	15907	657	1524	23444	1978	230942	70679	9685
4	46356	22631	41346	67632	1968	2454	24358	22315	260520	41706
5	40201	63176	13496	41267	44634	1906	1257	42981	24180	88120
6	12631	29048	25719	7748	19002	22417	918	3206	6919	5829
7	1679	5752	8872	15599	3620	8100	9279	1611	422	4138
8	974	582	1616	5292	4937	2012	3056	6758	426	382
9	897	438	218	655	1628	2016	826	2638	1692	618
10	123	189	175	182	316	740	1043	900	529	2043
+gp	802	242	271	286	109	293	534	1652	584	1870
0 TOTALNUM	109599	148403	107620	139318	77738	63382	43249	313003	365951	154391
TONSLAND	118578	161778	136397	181726	130820	88257	78905	266153	322226	221157
SOPCOF %	84	84	97	97	110	100	127	90	83	109

Table 5.1 Catch numbers at age (continued)

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	10037	13994	55967	47311	17540	627	486	883	1173	1271
4	14088	13454	22043	18812	35290	22878	2561	900	2636	1019
5	33871	6810	7368	4076	10645	21794	22124	3372	1360	1899
6	49711	20796	2586	1389	1429	2971	10685	12203	2394	657
7	2135	40057	7781	1626	812	250	1034	2625	2506	950
8	1236	1247	11043	2596	546	504	162	344	1799	2619
9	92	1350	311	6215	1466	230	162	75	267	352
10	131	193	388	162	2310	842	72	80	37	87
+gp	934	1604	379	400	323	1460	963	649	292	77
0 TOTALNUM	112235	99505	107866	82587	70361	51556	38249	21131	12464	8931
TONSLAND	175758	137264	110158	95422	103623	87889	77153	46955	24600	20945
SOPCOF %	108	87	90	106	127	128	135	134	95	95

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	29624	23113	5031	1439	2157	1015	4421	11571	13487	3374
4	1695	68429	87170	12478	4986	2580	3564	11567	19457	47821
5	564	1565	64556	47890	16071	2142	2416	4099	13704	36333
6	1009	783	960	20429	25313	4046	3299	2642	4103	13264
7	943	896	597	397	3198	6221	4633	2894	1747	2057
8	886	393	376	178	147	840	3953	3327	1886	903
9	1763	702	212	74	1	134	461	3498	2105	1453
10	588	1144	230	88	28	42	83	486	1965	2769
+gp	281	987	738	446	177	71	54	84	323	2110
0 TOTALNUM	37353	98012	159870	83419	52078	17091	22884	40168	58777	110084
TONSLAND	45052	100563	154916	95255	58518	27182	36216	59922	82379	135186
SOPCOF %	102	95	101	100	102	98	96	102	100	99

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
AGE										
3	2003	1662	2280	1701	16839	1520	12971	5491	4743	5232
4	16109	6818	5633	11304	8039	29986	5230	35584	20251	13764
5	72644	36473	12603	9258	15365	6496	32049	9290	44162	28539
6	19145	73579	32832	8633	6073	5149	5279	19917	10353	34811
7	6417	13426	49478	13801	4466	2406	2941	2269	13653	4567
8	746	2944	5636	19469	6355	1657	1137	1425	1521	4767
9	361	573	778	2113	6204	1570	1161	443	2128	569
10	770	365	245	330	647	1744	1169	409	829	1215
+gp	1576	1897	748	490	446	437	1204	917	1137	85
0 TOTALNUM	119771	137737	110233	67099	64434	50965	63141	75745	98777	93549
TONSLAND	142448	178128	154359	100630	83195	68944	89640	96062	105700	124502
SOPCOF %	98	98	95	99	98	97	101	99	98	100

Table 5.2 Catch weights at age (kg)

Table 2 Catch weights at age (kg)

YEAR	1950	1951	1952	1953	1954
AGE					
3	0.766	0.766	0.766	0.766	0.766
4	1.07	1.07	1.07	1.07	1.07
5	1.36	1.36	1.36	1.36	1.36
6	1.675	1.675	1.675	1.675	1.675
7	1.926	1.926	1.926	1.926	1.926
8	2.186	2.186	2.186	2.186	2.186
9	2.461	2.461	2.461	2.461	2.461
10	2.751	2.751	2.751	2.751	2.751
+gp	3.238	3.238	3.238	3.238	3.238
0 SOPCOFAC	0.6119	0.7943	0.5577	0.6818	0.6581

Table 2 Catch weights at age (kg)

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766
4	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
5	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
6	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675
7	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926
8	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186
9	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461
10	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751
+gp	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238
0 SOPCOFAC	0.6325	0.7667	0.7803	0.8666	1.0349	0.9339	0.9761	0.923	0.848	0.7163
1										

Table 2 Catch weights at age (kg)

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766
4	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
5	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36
6	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675
7	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926
8	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186
9	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461
10	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751
+gp	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238
0 SOPCOFAC	0.8441	0.8352	0.9717	0.9738	1.1012	0.9954	1.2725	0.8968	0.8334	1.086

Table 5.2 (continued)

Table 2 Catch weights at age (kg)

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	0.766	0.766	0.766	0.766	0.766	0.766	0.766	0.766	1.033	1.218
4	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.408	1.632
5	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.36	1.71	2.038
6	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	2.149	2.852
7	1.926	1.926	1.926	1.926	1.926	1.926	1.926	1.926	2.469	2.845
8	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.186	2.748	3.218
9	2.461	2.461	2.461	2.461	2.461	2.461	2.461	2.461	3.069	3.605
10	2.751	2.751	2.751	2.751	2.751	2.751	2.751	2.751	3.687	4.065
+gp	3.238	3.238	3.238	3.238	3.238	3.238	3.238	3.238	4.516	4.667
0 SOPCOFAC	1.0815	0.868	0.8956	1.0593	1.2663	1.278	1.3498	1.3424	0.9535	0.9491

Table 2 Catch weights at age (kg)

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	0.835	0.612	0.497	0.55	0.684	0.793	0.941	0.906	0.94	0.614
4	1.29	1.064	0.765	0.908	0.84	1.172	1.281	1.263	1.204	0.906
5	1.816	1.539	1.179	1.097	0.998	1.397	1.556	1.535	1.487	1.287
6	2.174	1.944	1.724	1.357	1.176	1.624	1.797	1.747	1.748	1.602
7	2.301	2.362	2.135	1.537	1.546	1.885	2.044	2.043	1.994	1.968
8	2.835	2.794	2.551	1.704	1.713	2.112	2.079	2.2	2.237	2.059
9	3.253	3.25	3.009	2.403	1.949	2.653	2.311	2.298	2.417	2.39
10	3.721	3.643	3.414	2.403	2.14	3.102	2.788	2.494	2.654	2.545
+gp	4.416	5.283	4.213	2.571	2.685	3.338	3.219	2.652	3.026	2.893
0 SOPCOFAC	1.0242	0.9508	1.0078	1.0045	1.023	0.9843	0.9639	1.0207	0.9969	0.9945

Table 2 Catch weights at age (kg)

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
AGE										
3	0.739	0.683	0.682	0.748	0.826	0.853	0.751	0.714	0.587	0.654
4	0.808	0.868	1.028	0.974	1.079	1.186	1.104	1.014	0.846	0.897
5	1.107	1.045	1.151	1.262	1.261	1.395	1.459	1.363	1.049	1.19
6	1.556	1.363	1.369	1.433	1.485	1.588	1.709	1.63	1.309	1.507
7	1.838	1.71	1.637	1.641	1.634	1.808	1.921	1.948	1.303	1.803
8	2.234	1.886	1.856	1.863	1.798	1.989	2.182	2.074	1.909	2.047
9	2.416	2.214	2.073	2.069	2.032	2.264	2.331	2.252	1.593	2.292
10	2.602	2.37	2.5	2.335	2.237	2.415	2.609	2.413	1.828	2.554
+gp	3.13	2.675	2.554	2.81	2.712	2.892	2.981	2.737	2.312	2.955
0 SOPCOFAC	0.9759	0.9832	0.9505	0.9888	0.9792	0.9741	1.0098	0.9903	0.9785	0.9973

Table 5.3 Natural Mortality (M) at age

Run title : NEA Haddock (SVPA AKHAD06)

At 8/03/2006 17:49

Table 4 Natural Mortality (M) at age

YEAR	1950	1951	1952	1953	1954
AGE					
3	0.3371	0.3371	0.3371	0.3371	0.3371
4	0.2309	0.2309	0.2309	0.2309	0.2309
5	0.2175	0.2175	0.2175	0.2175	0.2175
6	0.2028	0.2028	0.2028	0.2028	0.2028
7	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371
4	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309
5	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175
6	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1										

Table 4 Natural Mortality (M) at age

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371
4	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309
5	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175
6	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 5.3 (continued)

Table 4 Natural Mortality (M) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.3371	0.2103
4	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2309	0.2
5	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2175	0.2
6	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2028	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	0.2	0.6443	0.2	0.4677	0.2	0.3738	0.2	0.2063	0.2673	0.3041
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2288	0.219
5	0.2	0.2	0.2	0.2024	0.2	0.2	0.2	0.2	0.3036	0.2137
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2009
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4 Natural Mortality (M) at age

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
AGE										
3	0.3799	0.86	0.5245	0.2518	0.202	0.234	0.2199	0.3783	0.4929	0.2617
4	0.3843	0.3243	0.257	0.2637	0.2	0.2099	0.2016	0.2143	0.2963	0.2502
5	0.3163	0.2271	0.2316	0.2293	0.2	0.2122	0.2	0.2052	0.213	0.213
6	0.2107	0.2258	0.2113	0.2	0.2	0.2081	0.2	0.2013	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
+gp	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 5.4 Extended Survivors Analysis

Lowestoft VPA Version 3.1
8/03/2006 15:48
Extended Survivors Analysis
NEA Haddock (XSA WKHAD06)

CPUE data from file fleet

Catch data for 55 years. 1950 to 2004. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
FLT01: Russian BT su	1990	2004	1	7	0.9	1
FLT02: Norwegian aco	1990	2004	1	7	0.99	1
FLT04: Norwegian BT	1990	2004	1	8	0.99	1

Time series weights :
Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :
Catchability dependent on stock size for ages < 7

Regression type = C
Minimum of 5 points used for regression
Survivor estimates shrunk to the population mean for ages < 7

Catchability independent of age for ages >= 9

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = .500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations
29 and 30 = .00178

Final year F values

Age	1	2	3	4	5	6	7	8	9	10
Iteration 29	0.0001	0.0022	0.0292	0.1215	0.2458	0.509	0.3082	0.3823	0.2931	0.5966
Iteration 30	0.0001	0.0022	0.0292	0.1215	0.2458	0.5089	0.3081	0.382	0.2925	0.5961

Regression weights

	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Table 5.4 (continued)

Fishing mortalities

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0	0	0	0.001	0	0	0	0	0	0
2	0	0.002	0.001	0.005	0.005	0.002	0.004	0.001	0.001	0.002
3	0.024	0.022	0.024	0.035	0.083	0.019	0.046	0.021	0.027	0.029
4	0.09	0.122	0.143	0.198	0.239	0.211	0.086	0.174	0.113	0.122
5	0.256	0.343	0.383	0.391	0.471	0.313	0.368	0.216	0.345	0.246
6	0.461	0.491	0.614	0.504	0.492	0.284	0.456	0.412	0.4	0.509
7	0.731	0.703	0.75	0.576	0.535	0.367	0.261	0.362	0.556	0.308
8	0.43	0.926	0.741	0.771	0.577	0.387	0.296	0.195	0.441	0.382
9	0.352	0.702	0.677	0.698	0.601	0.269	0.518	0.179	0.497	0.293
10	0.528	0.737	0.757	0.696	0.474	0.333	0.329	0.346	0.595	0.596

1

XSA population numbers (Thousands)

AGE YEAR	1	2	3	4	5	6	7	8	9	10
1995	4280000	368000	104000	226000	376000	57500	13700	2360	1340	2080
1996	2340000	365000	116000	69600	141000	212000	29400	5390	1260	774
1997	1590000	117000	124000	47900	44500	79500	104000	11900	1750	510
1998	2430000	323000	55600	71800	32100	24100	34800	40000	4650	727
1999	1770000	146000	233000	41800	45200	17300	11900	16000	15200	1890
2000	2330000	481000	90800	175000	26900	23100	8650	5710	7370	6810
2001	1530000	475000	324000	70500	115000	15900	14100	4900	3170	4610
2002	4030000	581000	327000	248000	52900	65300	8260	8910	2990	1550
2003	5820000	573000	229000	219000	168000	34700	35400	4710	6000	2040
2004	1870000	598000	207000	136000	146000	96500	19000	16600	2480	2990

Estimated population abundance at 1st Jan 2005

0	341000	326000	155000	94000	92100	47500	11500	9280	1520

Taper weighted geometric mean of the VPA populations:

2270000	348000	166000	108000	69100	35800	16400	7750	3550	1830

Standard error of the weighted Log(VPA populations) :

0.6189	0.69	0.7321	0.8245	0.8795	0.883	0.8741	0.9003	0.9314	1.025

Table 5.4 (continued)

Log catchability residuals.

Fleet : FLT01: Russian BT su

Age	1990	1991	1992	1993	1994
1	99.99	0.37	0.38	-0.37	-0.72
2	99.99	0.23	0.32	0.19	-0.01
3	99.99	-0.01	0.34	0.2	0.14
4	99.99	-0.22	-0.21	0.51	0.04
5	99.99	-0.31	-0.31	0.18	0.14
6	99.99	-0.48	0.31	0.49	-0.02
7	99.99	0.48	0.63	0.81	-0.47
8	No data for this fleet at this age				

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.47	-0.43	99.99	-0.41	0.67	0.34	-0.05	0.03	0.4	0.1
2	-0.44	-0.28	-0.09	99.99	0.3	0.03	0.02	-0.04	0.22	-0.22
3	-0.29	-0.19	-0.37	0.39	99.99	0.15	-0.1	0.07	0.14	-0.28
4	-0.5	0.02	0.06	-0.05	0.36	99.99	-0.24	0.25	0.11	-0.25
5	-0.38	0.59	-0.57	-0.38	0.3	0.5	99.99	0.15	0.11	-0.31
6	0.01	0.37	-0.5	-0.7	-0.01	-0.2	0.29	99.99	0.34	0.12
7	0.3	1.27	-1.01	0.32	-0.25	-0.5	-0.4	0.23	99.99	-0.43
8	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	7
Mean Log q	-7.3335
S.E(Log q)	0.6433

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	0.88	0.344	8.98	0.49	13	0.45	-8.19
2	0.67	2.591	9.15	0.88	13	0.24	-7.3
3	0.59	3.263	9.01	0.88	13	0.26	-6.88
4	0.7	2.585	8.15	0.9	13	0.29	-6.66
5	0.65	2.415	8.27	0.85	13	0.41	-6.72
6	0.77	1.611	7.64	0.85	13	0.4	-6.8

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	1.14	-0.47	7.01	0.57	13	0.77	-7.33

Table 5.4 (continued)

Fleet : FLT02: Norwegian aco

Age	1990	1991	1992	1993	1994
1	0.4	0.35	0.61	0.29	0.26
2	0.05	0.22	-0.01	0.17	-0.16
3	0.19	-0.25	0.23	0.09	-0.23
4	0.05	-0.47	-0.39	0.4	0.05
5	-0.01	99.99	99.99	0.14	0.26
6	-0.28	99.99	99.99	99.99	-0.09
7	0.47	-1.1	99.99	99.99	99.99
8	No data for this fleet at this age				

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.06	-1.1	99.99	-0.66	0.58	0.11	-0.22	-0.2	0.31	0.02
2	-0.23	-0.17	0.09	99.99	0.01	0.07	0.09	-0.01	-0.03	0.03
3	0.09	-0.1	-0.06	0.07	99.99	-0.07	-0.11	0.16	-0.04	0.1
4	-0.12	-0.2	0.14	-0.12	0.61	99.99	-0.22	0.27	-0.13	-0.18
5	-0.25	-0.01	-0.11	0.08	0.37	-0.62	99.99	0.33	0.05	-0.16
6	0.14	0	0.25	-0.38	0.42	-0.48	0	99.99	0.51	-0.27
7	99.99	-0.07	0.8	-0.36	-0.02	99.99	99.99	99.99	99.99	99.99
8	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	7
Mean Log q	-6.326
S.E(Log q)	0.6105

Regression statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Log q
1	1.02	-0.071	4.91	0.51	14	0.51	-5.13
2	0.7	4.675	7.55	0.96	14	0.12	-5.25
3	0.66	5.483	7.61	0.97	14	0.14	-5.29
4	0.67	2.736	7.42	0.89	14	0.31	-5.42
5	0.59	3.229	7.9	0.89	12	0.31	-5.64
6	0.68	2.125	7.68	0.86	11	0.36	-6.28

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
7	0.7	1.03	7.53	0.84	6	0.43	-6.33

Table 5.4 (continued)

Fleet : FLT04: Norwegian BT

Age	1990	1991	1992	1993	1994
1	0.23	0.46	0.21	0.11	-0.56
2	-0.21	0.12	-0.39	0.08	-0.02
3	-0.24	-0.33	0	-0.23	-0.03
4	0.3	-0.42	-0.51	-0.1	0.01
5	0.23	0.08	-0.12	-0.35	0.22
6	-0.46	-0.24	0.22	-0.24	0.22
7	1.06	0.32	-0.51	-0.61	99.99
8	99.99	1.04	-0.46	-0.21	0.22

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.15	-0.39	99.99	-0.78	0.1	0.14	0.08	0.07	0.36	0.38
2	-0.26	-0.01	0.13	99.99	-0.14	0.05	0.09	0.22	-0.03	0.05
3	0.27	0.12	-0.06	-0.1	99.99	-0.03	-0.05	0.02	0.07	0.19
4	0.38	0.15	0.23	-0.3	0.09	99.99	-0.03	-0.25	-0.05	0.27
5	-0.01	0.1	-0.08	0.15	0.01	0.02	99.99	-0.11	-0.1	0.06
6	0.32	-0.01	-0.12	-0.16	0.04	-0.3	0.1	99.99	0.41	-0.14
7	0.87	1.44	1.06	0.42	-0.28	-1.23	-0.73	-0.5	99.99	-0.29
8	99.99	-0.04	0.92	0.19	0.46	-0.64	99.99	-1.28	0.3	99.99

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	7	8
Mean Log q	-7.2708	-7.427
S.E(Log q)	0.8502	0.6929

Regression
statistics :

Ages with q dependent on year class strength

Age	Slope	t-value	Intercept	Square	No Pts	Reg s.e	Mean Log q
1	1.02	-0.076	4.59	0.64	14	0.39	-4.78
2	0.6	4.571	8.11	0.94	14	0.17	-4.95
3	0.67	4.732	7.4	0.96	14	0.16	-5.14
4	0.68	3.1	7.41	0.92	14	0.27	-5.47
5	0.52	9.384	8.48	0.98	14	0.15	-6.04
6	0.56	4.74	8.25	0.93	14	0.26	-6.53

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	ntercept	Square	No Pts	Reg s.e	Mean Q
7	0.56	3.154	8.37	0.86	13	0.34	-7.27
8	0.84	0.578	7.7	0.66	11	0.61	-7.43

Table 5.4 (continued)

Terminal year survivor and F summaries :

Age 1 Catchability dependent on age and year class strength

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	375888	0.476	0	0	1	0.222	0
FLT02: Norwegian aco	348534	0.536	0	0	1	0.175	0
FLT04: Norwegian BT	499112	0.411	0	0	1	0.297	0
P shrinkage mean	347537	0.69				0.105	0
F shrinkage mean	170478	0.5				0.201	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
341410	0.22	0.21	5	0.95	0

1

Age 2 Catchability dependent on age and year class strength

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	301697	0.264	0.259	0.98	2	0.289	0.002
FLT02: Norwegian aco	354354	0.268	0.113	0.42	2	0.28	0.002
FLT04: Norwegian BT	375544	0.254	0.139	0.55	2	0.312	0.002
P shrinkage mean	166396	0.73				0.038	0.004
F shrinkage mean	259377	0.5				0.081	0.003

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
326426	0.14	0.09	8	0.666	0.002

Table 5.4 (continued)

Age 3 Catchability dependent on age and year class strength

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	151600	0.194	0.162	0.83	3	0.309	0.03
FLT02: Norwegian aco	156171	0.197	0.072	0.36	3	0.301	0.029
FLT04: Norwegian BT	167863	0.19	0.068	0.36	3	0.324	0.027
P shrinkage mean	107839	0.82				0.018	0.042
F shrinkage mean	114807	0.5				0.048	0.039

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
155053	0.11	0.06	11	0.521	0.029

1

Age 4 Catchability dependent on age and year class strength

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	89483	0.164	0.088	0.53	4	0.318	0.127
FLT02: Norwegian aco	86358	0.17	0.048	0.28	4	0.297	0.132
FLT04: Norwegian BT	111865	0.16	0.052	0.32	4	0.333	0.103
P shrinkage mean	69127	0.88				0.013	0.162
F shrinkage mean	67521	0.5				0.039	0.165

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
94022	0.09	0.05	14	0.524	0.122

Table 5.4 (continued)

Age 5 Catchability dependent on age and year class strength

Year class = 1999

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	95735	0.155	0.084	0.54	5	0.291	0.237
FLT02: Norwegian aco	92591	0.152	0.067	0.44	5	0.305	0.245
FLT04: Norwegian BT	96018	0.142	0.03	0.21	5	0.352	0.237
P shrinkage mean	35822	0.88				0.013	0.54
F shrinkage mean	62323	0.5				0.04	0.345

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
92099	0.08	0.05	17	0.545	0.246

1

Age 6 Catchability dependent on age and year class strength

Year class = 1998

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	53604	0.151	0.09	0.59	6	0.263	0.462
FLT02: Norwegian aco	48470	0.147	0.1	0.68	6	0.286	0.501
FLT04: Norwegian BT	43492	0.132	0.046	0.35	6	0.372	0.545
P shrinkage mean	16404	0.87				0.02	1.072
F shrinkage mean	61847	0.5				0.06	0.412

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
47487	0.08	0.06	20	0.686	0.509

Table 5.4 (continued)

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 1997

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	11952	0.146	0.114	0.78	7	0.292	0.297
FLT02: Norwegian aco	12228	0.143	0.138	0.96	6	0.285	0.291
FLT04: Norwegian BT	11194	0.13	0.122	0.93	7	0.363	0.314
F shrinkage mean	7931	0.5				0.06	0.419

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
11461	0.08	0.07	21	0.836	0.308

1

Age 8 Catchability constant w.r.t. time and dependent on age

Year class = 1996

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	1	0	0	0	0	0	0
FLT02: Norwegian aco	1	0	0	0	0	0	0
FLT04: Norwegian BT	1	0	0	0	0	0	0
F shrinkage mean	9280	0.5				1	0.382

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
9280	0.5	0	1	0	0.382

Table 5.4 (continued)

Age 9 Catchability constant w.r.t. time and dependent on age

Year class = 1995

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	1914	0.156	0.1	0.64	7	0.256	0.238
FLT02: Norwegian aco	1489	0.155	0.195	1.26	6	0.23	0.297
FLT04: Norwegian BT	1557	0.142	0.07	0.5	8	0.362	0.286
F shrinkage mean	999	0.5				0.152	0.416

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1518	0.11	0.07	22	0.705	0.293

1

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 9

Year class = 1994

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
FLT01: Russian BT su	1112	0.159	0.09	0.57	7	0.235	0.688
FLT02: Norwegian aco	1238	0.156	0.128	0.82	6	0.223	0.636
FLT04: Norwegian BT	1028	0.143	0.131	0.92	8	0.331	0.727
F shrinkage mean	2817	0.5				0.212	0.329

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1350	0.13	0.11	22	0.876	0.596

Table 5.5 Fishing mortality (F) at age

Run title : NEA Haddock (SVPA AKHAD06)
At 8/03/2006 17:49
Traditional vpa using file input for terminal F

Table 8 Fishing mortality (F) at age

YEAR	1950	1951	1952	1953	1954
AGE					
3	0.0491	0.1269	0.1049	0.0647	0.0553
4	0.5798	0.2136	0.5352	0.3818	0.2392
5	0.8178	0.6286	0.5796	0.5324	0.3061
6	0.8116	0.9125	0.8878	0.4893	0.4141
7	1.157	0.8053	0.9961	0.7145	0.6139
8	1.0055	1.0036	1.2502	0.6589	0.8609
9	0.6504	1.4256	1.3695	0.5162	1.3582
10	0.946	1.0901	1.2251	0.6331	0.9584
+gp	0.946	1.0901	1.2251	0.6331	0.9584
FBAR 4- 7	0.8415	0.64	0.7497	0.5295	0.3933

Table 8 Fishing mortality (F) at age

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	0.0227	0.1027	0.0406	0.0256	0.0649	0.1829	0.1543	0.1817	0.1099	0.0729
4	0.1315	0.1701	0.2434	0.1708	0.1701	0.3707	0.4767	0.5828	0.6633	0.3107
5	0.4857	0.2764	0.3715	0.5737	0.335	0.5145	0.6916	1.0537	0.9293	0.6869
6	0.4685	0.8116	0.4067	0.5209	0.5577	0.6524	0.7507	1.0606	1.0254	0.87
7	1.0131	0.6249	0.8167	0.9643	0.6025	0.5207	0.8335	0.7002	1.0012	0.8437
8	0.6211	0.9345	0.4513	0.8693	0.4321	0.7026	0.8825	0.904	0.6536	0.9605
9	0.43	0.3985	0.6298	0.743	0.8446	1.1478	0.9636	1.1812	1.3586	1.3821
10	0.6948	0.6588	0.6371	0.8688	0.6304	0.7976	0.9015	0.9374	1.0158	1.0779
+gp	0.6948	0.6588	0.6371	0.8688	0.6304	0.7976	0.9015	0.9374	1.0158	1.0779
FBAR 4- 7	0.5247	0.4708	0.4596	0.5574	0.4163	0.5146	0.6881	0.8493	0.9048	0.6778

1
Run title : NEA Haddock (SVPA AKHAD06)

At 8/03/2006 17:49

Traditional vpa using file input for terminal F

Table 8 Fishing mortality (F) at age

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	0.0604	0.1175	0.0554	0.0376	0.0911	0.1544	0.0211	0.2603	0.3072	0.2044
4	0.2336	0.3771	0.3009	0.3867	0.1654	0.2283	0.2625	0.3827	0.5886	0.3331
5	0.4639	0.5908	0.4183	0.5738	0.4933	0.2456	0.1799	1.0609	0.9835	0.4163
6	0.6977	0.7428	0.5199	0.4588	0.581	0.5033	0.1812	0.9485	0.477	0.6949
7	0.6762	0.8234	0.5329	0.7021	0.4049	0.5297	0.4031	0.5512	0.2977	0.5912
8	0.5955	0.5278	0.5805	0.7159	0.5022	0.4138	0.3894	0.5804	0.2726	0.4815
9	1.0492	0.5925	0.3839	0.4945	0.5015	0.3945	0.2977	0.6922	0.2768	0.7995
10	0.7832	0.6549	0.5027	0.6448	0.4733	0.4492	0.3649	0.6145	0.2825	0.6304
+gp	0.7832	0.6549	0.5027	0.6448	0.4733	0.4492	0.3649	0.6145	0.2825	0.6304
FBAR 4- 7	0.5178	0.6335	0.443	0.5303	0.4112	0.3767	0.2567	0.7358	0.5867	0.5089

Table 5.5 (continued)

Table 8 Fishing mortality (F) at age

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	0.2335	0.2968	0.6965	0.3198	0.1326	0.0261	0.0456	0.0664	0.1636	0.1237
4	0.5747	0.6292	1.2518	0.6054	0.4689	0.2823	0.1548	0.122	0.3172	0.2266
5	0.5119	0.6343	0.9113	0.8731	0.8838	0.6188	0.4999	0.3219	0.2807	0.4058
6	0.4456	0.7036	0.5379	0.4296	0.9249	0.6759	0.7294	0.5818	0.4041	0.2147
7	0.5984	0.7989	0.6309	0.7892	0.4836	0.3982	0.5313	0.3923	0.2225	0.2774
8	0.3499	0.872	0.5338	0.4453	0.6806	0.6355	0.4887	0.3366	0.513	0.3816
9	0.2019	0.8092	0.5553	0.6613	0.4888	0.6962	0.4304	0.441	0.4756	0.1756
10	0.3844	0.8375	0.5781	0.6382	0.5556	0.5826	0.4878	0.3925	0.4067	0.2786
+gp	0.3844	0.8375	0.5781	0.6382	0.5556	0.5826	0.4878	0.3925	0.4067	0.2786
FBAR 4- 7	0.5326	0.6915	0.833	0.6743	0.6903	0.4938	0.4788	0.3545	0.3061	0.2811

Table 8 Fishing mortality (F) at age

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	0.1196	0.0612	0.0503	0.0314	0.0942	0.0324	0.0468	0.0628	0.0225	0.0128
4	0.2425	0.4409	0.4577	0.1696	0.1688	0.1556	0.1677	0.166	0.1453	0.1087
5	0.1888	0.3693	1.0017	0.4938	0.3423	0.1016	0.2137	0.2957	0.319	0.4501
6	0.3928	0.4321	0.4072	1.0936	0.532	0.1346	0.2241	0.3818	0.5429	0.6309
7	0.5407	0.7319	0.6956	0.2935	0.4834	0.238	0.2247	0.313	0.4699	0.5821
8	0.4511	0.455	0.8038	0.4579	0.1679	0.2235	0.2339	0.2496	0.3459	0.4759
9	0.4803	0.7953	0.4773	0.355	0.004	0.2274	0.1839	0.3346	0.2474	0.491
10	0.4938	0.6678	0.6679	0.372	0.2199	0.2307	0.2147	0.3003	0.3185	0.5948
+gp	0.4938	0.6678	0.6679	0.372	0.2199	0.2307	0.2147	0.3003	0.3185	0.5948
FBAR 4- 7	0.3412	0.4936	0.6406	0.5126	0.3816	0.1575	0.2076	0.2891	0.3693	0.443

Table 8 Fishing mortality (F) at age

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	FBAR **-**
AGE											
3	0.0236	0.0218	0.0241	0.0354	0.0836	0.0191	0.046	0.0205	0.0267	0.0292	0.0255
4	0.0904	0.1227	0.1439	0.1984	0.2397	0.2112	0.0859	0.1744	0.1132	0.1215	0.1364
5	0.2567	0.3439	0.3826	0.3905	0.4705	0.3127	0.368	0.2168	0.3453	0.2458	0.2693
6	0.4626	0.492	0.613	0.5042	0.4915	0.2845	0.4557	0.4119	0.3997	0.5089	0.4402
7	0.732	0.7029	0.7494	0.5753	0.5345	0.3678	0.2623	0.3617	0.5553	0.3081	0.4084
8	0.4318	0.9235	0.7392	0.7679	0.5751	0.3871	0.297	0.1956	0.4406	0.382	0.3394
9	0.354	0.7021	0.6772	0.696	0.5994	0.2688	0.517	0.1802	0.4977	0.2925	0.3235
10	0.5277	0.7368	0.7574	0.6962	0.474	0.3329	0.3288	0.3455	0.5945	0.5961	0.512
+gp	0.5277	0.7368	0.7574	0.6962	0.474	0.3329	0.3288	0.3455	0.5945	0.5961	
FBAR 4- 7	0.3854	0.4154	0.4722	0.4171	0.4341	0.2941	0.293	0.2912	0.3534	0.2961	

Table 5.6 Stock numbers at age (start of year)

Run title : NEA Haddock (SVPA AKHAD06)
At 8/03/2006 17:49
Traditional vpa using file input for terminal F

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1950	1951	1952	1953	1954
AGE					
3	78320	646573	70915	1211408	143480
4	95534	53231	406553	45582	810602
5	69384	42470	34129	188974	24699
6	36962	24640	18223	15379	89275
7	45596	13404	8078	6123	7697
8	15745	11738	4905	2442	2454
9	4518	4716	3523	1150	1035
10	1941	1930	928	733	562
+gp	5287	2201	1348	2339	957
TOTAL	353287	800903	548602	1474132	1080761

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	60545	197841	61348	80285	380471	279861	126531	278704	321214	373824
4	96913	42250	127447	42051	55860	254545	166390	77406	165903	205436
5	506566	67451	28291	79308	28140	37407	139465	81996	34307	67844
6	14632	250762	41161	15699	35951	16195	17991	56190	22999	10898
7	48176	7478	90933	22377	7613	16806	6886	6934	15885	6735
8	3411	14321	3277	32898	6985	3412	8175	2450	2818	4779
9	849	1501	4605	1709	11292	3712	1384	2769	812	1200
10	218	452	825	2009	665	3973	964	432	696	171
+gp	218	418	408	1126	1168	1201	2624	1350	638	1040
TOTAL	731527	582475	358295	277461	528145	617112	470411	508231	565273	671927

1
Run title : NEA Haddock (SVPA AKHAD06)

Traditional vpa using file input for terminal F

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	119173	279111	347123	20962	20567	192197	111618	1178544	312057	61353
4	248088	80089	177163	234439	14412	13404	117571	78017	648511	163835
5	119518	155908	43601	104088	126418	9696	8468	71783	42237	285775
6	27461	60467	69474	23087	47178	62104	6102	5691	19990	12709
7	3728	11159	23489	33725	11915	21545	30655	4157	1800	10130
8	2372	1552	4010	11287	13682	6507	10386	16772	1961	1094
9	1497	1070	750	1837	4517	6779	3522	5761	7685	1223
10	247	429	485	418	917	2240	3741	2141	2361	4771
+gp	1609	550	750	657	316	887	1915	3930	2606	4367
TOTAL	523692	590335	666845	430501	239923	315358	293979	1366795	1039207	545257

Table 5.6 (continued)

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	56406	63665	128912	201834	165725	28662	12837	16160	9115	12082
4	35699	31880	33777	45859	104649	103608	19933	8755	10795	5525
5	93212	15951	13489	7668	19871	51978	62016	13553	6152	6240
6	151619	44949	6806	4362	2577	6606	22523	30266	7903	3738
7	5179	79285	18159	3245	2318	834	2744	8868	13810	4308
8	4592	2331	29200	7912	1207	1170	459	1321	4904	9051
9	553	2649	798	14019	4150	500	507	230	772	2404
10	450	370	966	375	5924	2084	204	270	121	393
+gp	3208	3078	943	926	828	3613	2730	2191	958	348
TOTAL	350921	244159	233050	286199	307248	199056	123954	81615	54530	44088

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	289373	526244	113047	58170	26437	38118	106515	210132	689389	307192
4	8651	210211	259880	88014	35312	19700	25394	83216	160554	515935
5	3606	5558	110742	134623	60820	24419	13804	17580	57712	110450
6	3405	2445	3145	33297	67106	35360	18061	9127	10709	30965
7	2469	1882	1299	1714	9132	32276	25304	11818	5101	5094
8	2673	1177	741	531	1046	4611	20828	16547	7075	2611
9	5060	1394	611	272	275	724	3019	13495	10555	4099
10	1651	2563	515	311	156	224	472	2057	7907	6748
+gp	789	2211	1653	1574	986	379	307	356	1300	5142
TOTAL	317676	753684	491635	318506	201270	155811	213704	364328	950300	988236

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	GMST 50-**	AMST 50-**
AGE													
3	103186	114718	123128	55236	231439	90178	321160	324864	228049	206503	0	121760	214678
4	223748	68925	47500	71144	41444	173935	70016	246188	218029	135637	154377	77139	135311
5	371767	139188	44084	31811	44816	26699	114148	52521	166899	144773	93533	44085	76460
6	56870	209611	78632	23854	17117	22920	15794	64682	34440	95491	91500	21469	37465
7	13477	29003	102255	34480	11796	8573	14005	8198	35031	18906	46999	9892	17352
8	2330	5307	11757	39572	15881	5659	4858	8821	4675	16461	11375	4556	7615
9	1328	1239	1725	4596	15032	7316	3146	2956	5939	2463	9198	2081	3450
10	2054	763	503	718	1876	6758	4578	1536	2021	2956	1505	924	1638
+gp	4204	3966	1535	1066	1293	1693	4715	3444	2772	207	1427		
TOTAL	778964	572721	411118	262476	380695	343731	552421	713209	697855	623398	409914		

Table 5.7 Stock biomass at age with SOP (start of year)

Run title : NEA Haddock (SVPA AKHAD06)

At 8/03/2006 17:49

Traditional vpa using file input for terminal F

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1950	1951	1952	1953	1954
AGE					
3	16774	179745	13842	289072	33050
4	38584	27905	149646	20511	352102
5	44157	35082	19795	133993	16906
6	33249	28769	14940	15413	86371
7	53850	20548	8695	8058	9777
8	23316	22562	6620	4030	3908
9	7962	10788	5658	2259	1961
10	3944	5090	1719	1660	1228
+gp	12068	6521	2804	5949	2349
TOTALBIO	233905	337010	223718	480944	507652

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	13402	53091	16754	24350	137811	91475	43228	90034	95340	93713
4	40453	21380	65633	24050	38154	156892	107195	47153	92856	97115
5	333193	53785	22958	71474	30287	36332	141580	78709	30257	50537
6	13603	282626	47212	19998	54692	22232	25815	76238	28671	11474
7	58805	11066	136940	37424	15206	30291	12973	12351	25999	9310
8	5221	26572	6189	68990	17493	7712	19310	5472	5784	8283
9	1547	3314	10349	4265	33656	9984	3890	7361	1984	2476
10	457	1152	2137	5779	2287	12318	3126	1324	1959	406
+gp	514	1197	1187	3640	4507	4183	9555	4649	2018	2779
TOTALBIO	467195	454181	309359	259968	334093	371418	366674	323292	284868	276094

1

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	35207	81589	118051	7144	7927	66956	49712	369903	91027	23319
4	138206	44147	113614	150671	10475	8805	98741	46175	356724	117425
5	104916	135421	44060	105412	144781	10037	11206	66946	36610	322753
6	34073	74237	99233	33048	76371	90868	11415	7502	24491	20289
7	6073	17988	44050	63382	25322	41388	75285	7194	2895	21231
8	4844	3137	9430	26599	36463	15673	31984	36397	3956	2875
9	3640	2575	2098	5153	14325	19434	12908	14878	18446	3824
10	691	1190	1563	1352	3354	7401	15806	6375	6532	17199
+gp	5064	1712	2720	2386	1300	3292	9092	13146	8101	17687
TOTALBIO	332715	361996	434819	395146	320318	263855	316147	568516	548781	546603

Table 5.7 (continued)

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	21351	19342	40410	74830	73449	16850	10223	12148	4172	4472
4	25481	18264	19966	32061	87459	117849	22601	12223	10293	4562
5	104839	14400	12564	8447	26169	75730	113844	23470	9209	8943
6	241038	57355	8960	6793	4796	13931	48035	75568	13338	7521
7	10811	132826	31390	6634	5665	2388	7852	24284	31340	9322
8	12018	4896	63289	20281	3698	4516	1678	4574	11691	24742
9	1724	6624	2058	42768	15133	2090	2377	977	2231	6708
10	1616	1067	2872	1319	24906	9188	1017	1407	414	1287
+gp	12943	9964	3152	3658	3913	18471	14152	11973	3881	1310
TOTALBIO	431819	264738	184660	196790	245188	261013	221778	166623	86570	68867

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	100771	140105	34178	20451	11359	14633	39015	70781	178682	76373
4	6291	127922	138810	48626	23480	14931	17623	58610	99233	256539
5	4912	5813	110489	112240	54751	24277	15701	19918	62134	106544
6	7114	4254	4881	46826	81691	43159	24721	15279	16547	46498
7	6752	4617	3064	3426	17096	49878	40000	22317	10730	10183
8	7582	3582	2316	1519	2622	10258	39550	34456	16152	6698
9	17413	4294	2280	979	933	2067	7829	32784	25779	11087
10	5683	9259	1911	1292	644	831	1516	6529	21833	19125
+gp	3112	7904	7013	6468	4588	1655	1235	1354	4548	16107
TOTALBIO	159630	307749	304942	241826	197165	161689	187190	262028	435637	549155

Table 14 Stock biomass at age with SOP (start of year) Tonnes

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
AGE										
3	27187	31581	36282	17477	77051	24597	103776	90083	58018	63842
4	102622	34561	23930	40799	24349	108440	37471	143847	113072	67635
5	286605	102636	33942	26735	39933	24708	115264	43691	151880	121280
6	76031	232877	80722	27123	20113	28579	21212	89679	40102	125707
7	25778	51043	145797	49093	17672	13278	23900	14209	62729	29791
8	5617	12575	24922	73949	28146	10584	9763	18346	9926	37265
9	3940	3557	4691	12089	33559	15679	7338	7025	14645	6363
10	6274	2604	1596	2328	5640	17577	11926	4107	5517	8608
+gp	13251	13765	5645	3941	4661	5724	14521	10026	8354	656
TOTALBIO	547304	485198	357527	253534	251125	249166	345171	421012	464244	461147

Table 5.8 Spawning stock biomass with SOP (spawning time) Tonnes

Run title : NEA Haddock (SVPA AKHAD06)

At 8/03/2006 17:49

Traditional vpa using file input for terminal F

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1950	1951	1952	1953	1954
AGE					
3	168	1797	138	2891	331
4	3858	2790	14965	2051	35210
5	14130	11226	6334	42878	5410
6	21280	18412	9561	9864	55277
7	45773	17466	7390	6849	8311
8	22151	21434	6289	3828	3713
9	7803	10573	5545	2214	1922
10	3904	5039	1701	1643	1216
+gp	12068	6521	2804	5949	2349
TOTSPBIO	131134	95258	54728	78167	113738

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
AGE										
3	134	531	168	243	1378	915	432	900	953	937
4	4045	2138	6563	2405	3815	15689	10720	4715	9286	9711
5	106622	17211	7346	22872	9692	11626	45306	25187	9682	16172
6	8706	180881	30216	12798	35003	14229	16522	48792	18349	7344
7	49984	9406	116399	31810	12925	25747	11027	10499	22099	7913
8	4960	25244	5879	65540	16618	7326	18345	5199	5495	7869
9	1516	3248	10142	4179	32983	9785	3812	7213	1944	2426
10	453	1140	2116	5721	2264	12194	3094	1311	1939	402
+gp	514	1197	1187	3640	4507	4183	9555	4649	2018	2779
TOTSPBIO	176934	240994	180016	149209	119185	101694	118814	108465	71766	55555

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AGE										
3	352	816	1181	71	79	670	497	3699	910	233
4	13821	4415	11361	15067	1047	881	9874	4617	35672	11743
5	33573	43335	14099	33732	46330	3212	3586	21423	11715	103281
6	21807	47512	63509	21151	48878	58156	7305	4801	15674	12985
7	5162	15290	37442	53874	21524	35180	63992	6115	2461	18046
8	4602	2980	8958	25269	34640	14889	30385	34577	3758	2732
9	3567	2523	2056	5050	14038	19045	12649	14580	18077	3747
10	684	1179	1548	1338	3321	7327	15648	6311	6466	17027
+gp	5064	1712	2720	2386	1300	3292	9092	13146	8101	17687
TOTSPBIO	88633	119761	142874	157938	171157	142651	153028	109270	102835	187481

Table 5.8 (continued)

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AGE										
3	214	193	404	748	734	169	102	121	42	45
4	2548	1826	1997	3206	8746	11785	2034	1222	1132	1095
5	33548	4608	4021	2703	8374	27263	40984	7980	3407	4203
6	154265	36707	5734	4347	3069	9334	31703	50630	8670	5791
7	9189	112902	26681	5639	4815	2030	6674	20641	26639	7923
8	11417	4652	60124	19267	3513	4200	1560	4254	10873	22762
9	1689	6491	2017	41913	14830	2028	2305	948	2164	6507
10	1600	1056	2843	1305	24657	8912	986	1365	402	1248
+gp	12943	9964	3152	3658	3913	18471	14152	11973	3881	1310
TOTSPBIO	227412	178400	106973	82786	72652	84191	100501	99134	57210	50885

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AGE										
3	1008	1401	342	205	114	146	390	708	1787	764
4	818	10234	9717	3890	2113	1792	2467	7033	8931	15392
5	2554	2209	29832	25815	14235	7283	5495	7967	22368	29832
6	5549	3445	3466	27627	44113	24600	15574	10390	12079	32084
7	6279	4294	2880	3083	14190	39902	32800	18969	9550	9266
8	7203	3510	2269	1488	2543	9642	36781	32389	15344	6430
9	16890	4251	2257	970	933	2046	7672	32129	25263	10976
10	5626	9167	1911	1292	644	831	1516	6464	21615	18934
+gp	3112	7904	7013	6468	4588	1655	1235	1354	4548	16107
TOTSPBIO	49039	46415	59686	70838	83474	87899	103932	117403	121485	139786

Table 15 Spawning stock biomass with SOP (spawning time) Tonnes

YEAR	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
AGE										
3	272	316	363	175	771	246	1038	901	580	638
4	5131	2074	1675	3672	2678	14097	3372	14385	7915	3382
5	57321	20527	7128	6416	11581	8154	42648	12670	45564	30320
6	46379	114110	38747	13290	11062	17433	14000	62776	24863	79195
7	22942	43387	110805	36820	13431	10755	20315	12503	56457	25620
8	5449	12198	23676	67294	25613	9632	9079	17428	9529	36147
9	3900	3521	4644	11968	32553	15208	7118	6885	14499	6300
10	6274	2604	1596	2328	5640	17402	11807	4066	5462	8608
+gp	13251	13765	5645	3941	4661	5724	14521	10026	8354	656
TOTSPBIO	160918	212500	194279	145904	107989	98651	123898	141640	173223	190866

Table 5.9 Summary (with SOP correction)

Run title : NEA Haddock (SVPA AKHAD06)

At 8/03/2006 17:49

Table 17 Summary (with SOP correction)

Traditional vpa using file input for terminal F

	ECRUITS Age 3	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	SOPCOFAC	FBAR 4- 7
1950	78320	233905	131134	132125	1.0076	0.6119	0.8415
1951	646573	337010	95258	120077	1.2605	0.7943	0.64
1952	70915	223718	54728	127660	2.3326	0.5577	0.7497
1953	1211408	480944	78167	123920	1.5853	0.6818	0.5295
1954	143480	507652	113738	156788	1.3785	0.6581	0.3933
1955	60545	467195	176934	202286	1.1433	0.6325	0.5247
1956	197841	454181	240994	213924	0.8877	0.7667	0.4708
1957	61348	309359	180016	123583	0.6865	0.7803	0.4596
1958	80285	259968	149209	112672	0.7551	0.8666	0.5574
1959	380471	334093	119185	88211	0.7401	1.0349	0.4163
1960	279861	371418	101694	154651	1.5208	0.9339	0.5146
1961	126531	366674	118814	193224	1.6263	0.9761	0.6881
1962	278704	323292	108465	187408	1.7278	0.923	0.8493
1963	321214	284868	71766	146224	2.0375	0.848	0.9048
1964	373824	276094	55555	99158	1.7849	0.7163	0.6778
1965	119173	332715	88633	118578	1.3379	0.8441	0.5178
1966	279111	361996	119761	161778	1.3508	0.8352	0.6335
1967	347123	434819	142874	136397	0.9547	0.9717	0.443
1968	20962	395146	157938	181726	1.1506	0.9738	0.5303
1969	20567	320318	171157	130820	0.7643	1.1012	0.4112
1970	192197	263855	142651	88257	0.6187	0.9954	0.3767
1971	111618	316147	153028	78905	0.5156	1.2725	0.2567
1972	1178544	568516	109270	266153	2.4357	0.8968	0.7358
1973	312057	548781	102835	322226	3.1334	0.8334	0.5867
1974	61353	546603	187481	221157	1.1796	1.086	0.5089
1975	56406	431819	227412	175758	0.7729	1.0815	0.5326
1976	63665	264738	178400	137264	0.7694	0.868	0.6915
1977	128912	184660	106973	110158	1.0298	0.8956	0.833
1978	201834	196790	82786	95422	1.1526	1.0593	0.6743
1979	165725	245188	72652	103623	1.4263	1.2663	0.6903
1980	28662	261013	84191	87889	1.0439	1.278	0.4938
1981	12837	221778	100501	77153	0.7677	1.3498	0.4788
1982	16160	166623	99134	46955	0.4737	1.3424	0.3545
1983	9115	86570	57210	24600	0.43	0.9535	0.3061
1984	12082	68867	50885	20945	0.4116	0.9491	0.2811
1985	289373	159630	49039	45052	0.9187	1.0242	0.3412
1986	526244	307749	46415	100563	2.1666	0.9508	0.4936
1987	113047	304942	59686	154916	2.5955	1.0078	0.6406
1988	58170	241826	70838	95255	1.3447	1.0045	0.5126
1989	26437	197165	83474	58518	0.701	1.023	0.3816
1990	38118	161689	87899	27182	0.3092	0.9843	0.1575
1991	106515	187190	103932	36216	0.3485	0.9639	0.2076
1992	210132	262028	117403	59922	0.5104	1.0207	0.2891
1993	689389	435637	121485	82379	0.6781	0.9969	0.3693
1994	307192	549155	139786	135186	0.9671	0.9945	0.443
1995	103186	547304	160918	142448	0.8852	0.9759	0.3854

Table 5.9 (continued)

1996	114718	485198	212500	178128	0.8382	0.9832	0.4154
1997	123128	357527	194279	154359	0.7945	0.9505	0.4722
1998	55236	253534	145904	100630	0.6897	0.9888	0.4171
1999	231439	251125	107989	83195	0.7704	0.9792	0.4341
2000	90178	249166	98651	68944	0.6989	0.9741	0.2941
2001	321160	345171	123898	89640	0.7235	1.0098	0.293
2002	324864	421012	141640	96062	0.6782	0.9903	0.2912
2003	228049	464244	173223	105700	0.6102	0.9785	0.3534
2004	206503	461147	190866	124502	0.6523	0.9973	0.2961
Arith.							
Mean	214773	328905	121114	121936	1.0923	.4917	
0 Units	Thousands)	(Tonnes)	(Tonnes)	(Tonnes)			

Table 5.10 Control settings for the FLXSA analysis

Tolerance (for convergence)	1.00E-09
Maximum iterations	40
Minimum SE in estimate of N	0.3
SE of F when shrinking to mean F	0.5
Oldest age for which the two parameter model is used for catchability at age	6
Age after which catchability is not estimated. q at older ages is set to the value at this age	8
Shrinkage to mean N	TRUE
Shrinkage to mean F	TRUE
Number of years for shrinkage to F in terminal year	3
Tuning window	15
Number of years to be used in the time series weighting	20
Power to be used in the time series taper weighting	3

Table 5.11 Results from the FLXSA analysis

Year	SSB	Total biomass	Recruitment at age 3	fbar (ages 4-7)	Catch
1950	217901	388377	79134	0.841	132125
1951	121941	430186	654602	0.639	120077
1952	99612	406481	71603	0.750	127660
1953	116036	713928	1225714	0.529	123920
1954	175094	780924	145078	0.392	156788
1955	283785	748811	61164	0.524	202286
1956	318997	600759	200053	0.470	213924
1957	234065	401897	62057	0.458	123583
1958	174720	304161	81246	0.557	112672
1959	116735	327196	385759	0.415	88211
1960	110469	403518	284150	0.512	154651
1961	123578	381596	128366	0.686	193224
1962	119598	356102	282500	0.849	187408
1963	86027	340617	324608	0.907	146224
1964	78609	389970	377693	0.679	99158
1965	106214	398549	120279	0.518	118578
1966	145112	438320	281956	0.635	161778
1967	148584	452115	350591	0.443	136397
1968	163926	410078	21137	0.531	181726
1969	156950	293803	20805	0.411	130820
1970	144671	267953	194936	0.376	88257
1971	121406	251431	113248	0.255	78905
1972	123212	641940	1192837	0.738	266153
1973	124727	666375	315681	0.587	322226
1974	174427	508818	62126	0.508	221157
1975	212638	403956	57192	0.532	175758
1976	208071	309015	64971	0.692	137264
1977	120797	209154	131414	0.836	110158
1978	79029	188064	204356	0.675	95422
1979	58013	195830	167377	0.692	103623
1980	66468	206310	28927	0.494	87889
1981	75168	165971	12949	0.479	77153
1982	74530	125323	16333	0.354	46955
1983	60586	91696	9201	0.305	24600
1984	54209	73337	12144	0.280	20945
1985	48462	158042	293871	0.340	45052
1986	49445	328106	532258	0.492	100563
1987	60170	306779	113487	0.639	154916
1988	71708	243746	58472	0.509	95255
1989	82962	195032	26634	0.377	58518
1990	90647	166171	38463	0.157	27182
1991	109306	196498	107724	0.207	36216
1992	116741	259926	212279	0.289	59922
1993	123201	441993	697525	0.369	82379
1994	141516	558017	310592	0.442	135186
1995	166618	567414	104217	0.385	142448
1996	218819	499528	115884	0.415	178128
1997	207170	380860	124148	0.472	154359
1998	149562	259469	55629	0.417	100630

Table 5.11 (continued)

1999	111744	259162	233336	0.434	83195
2000	102534	258272	90615	0.293	68944
2001	123953	345910	327127	0.293	89640
2002	144504	431253	330887	0.290	96062
2003	179310	482946	234485	0.352	105700
2004	194891	470752	205935	0.292	124502

Table 5.12 FLRXSA Diagnostics and residuals

Index	First age	Last age	First year	Last year
Russian BT survey, total area, Nov-Dec, age 1-7	1	7	1983	2004
Norwegian acoustic, age 1-7, shifted	1	7	1980	2004
Norwegian BT survey, age 1-7, shifted	1	8	1982	2004

Index:	Russian BT survey, total area, Nov-Dec, age 1-7						
power model							
	slope	power					
1	9.93	0.738					
2	8.91	0.707					
3	9.04	0.585					
4	8.18	0.696					
5	8.25	0.654					
6	7.76	0.74					
linear catchability model							
	mean Q						
7	0.000647						
Residuals							
year / age	1	2	3	4	5	6	7
1983	0.937	1.79	0.663	0.145	-1.1	NA	NA
1984	0.682	0.528	0.823	0.22	-0.0816	-1.4	NA
1985	0.0246	0.533	0.355	0.254	0.19	0.0192	NA
1986	-0.0471	0.0705	-0.177	-0.0859	-0.0151	-0.973	-1.63
1987	0.0158	-0.0876	0.0736	-0.0667	-4.5E-06	-1.16	-1.29
1988	-0.149	0.0178	-0.0005	-0.277	-0.202	-0.182	-1.94
1989	-0.292	0.38	-0.103	-0.151	-0.0023	0.292	1.21
1990	NA	NA	NA	NA	NA	NA	NA
1991	0.286	0.155	0.00287	-0.14	-0.206	-0.315	0.497
1992	0.223	0.278	0.202	-0.138	-0.209	0.269	0.645
1993	-0.201	0.155	0.111	0.36	0.125	0.39	0.818
1994	-0.423	-0.0311	0.079	0.0327	0.0954	-0.0072	-0.462
1995	-0.336	-0.341	-0.164	-0.339	-0.24	-0.0021	0.313
1996	-0.237	-0.219	-0.105	0.0224	0.393	0.216	1.28
1997	NA	-0.123	-0.208	0.054	-0.371	-0.377	-1
1998	-0.233	NA	0.235	-0.022	-0.25	-0.479	0.326
1999	0.465	0.178	NA	0.264	0.202	0.0171	-0.248
2000	0.228	0.0176	0.095	NA	0.331	-0.126	-0.493
2001	0.0315	0.0129	-0.0642	-0.157	NA	0.235	-0.387
2002	-0.0137	-0.0342	0.0335	0.176	0.102	NA	0.245
2003	0.18	0.179	0.0718	0.0733	0.0685	0.249	NA
2004	0.054	-0.137	-0.156	-0.182	-0.206	0.0419	-0.414

Table 5.12 (continued)

Index:	Norwegian acoustic, age 1-7, shifted						
power model							
	slope	power					
1	7.12	0.796					
2	7.81	0.663					
3	7.64	0.653					
4	7.44	0.674					
5	7.89	0.599					
6	7.67	0.679					
linear catchability model							
	mean Q						
7	0.00185						
Residuals							
year / age	1	2	3	4	5	6	7
1983	0.937	1.79	0.663	0.145	-1.1	NA	NA
1984	0.682	0.528	0.823	0.22	-0.0816	-1.4	NA
1985	0.0246	0.533	0.355	0.254	0.19	0.0192	NA
1986	-0.0471	0.0705	-0.177	-0.0859	-0.0151	-0.973	-1.63
1987	0.0158	-0.0876	0.0736	-0.0667	-4.5E-06	-1.16	-1.29
1988	-0.149	0.0178	-0.0005	-0.277	-0.202	-0.182	-1.94
1989	-0.292	0.38	-0.103	-0.151	-0.0023	0.292	1.21
1990	NA	NA	NA	NA	NA	NA	NA
1991	0.286	0.155	0.00287	-0.14	-0.206	-0.315	0.497
1992	0.223	0.278	0.202	-0.138	-0.209	0.269	0.645
1993	-0.201	0.155	0.111	0.36	0.125	0.39	0.818
1994	-0.423	-0.0311	0.079	0.0327	0.0954	-0.0072	-0.462
1995	-0.336	-0.341	-0.164	-0.339	-0.24	-0.0021	0.313
1996	-0.237	-0.219	-0.105	0.0224	0.393	0.216	1.28
1997	NA	-0.123	-0.208	0.054	-0.371	-0.377	-1
1998	-0.233	NA	0.235	-0.022	-0.25	-0.479	0.326
1999	0.465	0.178	NA	0.264	0.202	0.0171	-0.248
2000	0.228	0.0176	0.095	NA	0.331	-0.126	-0.493
2001	0.0315	0.0129	-0.0642	-0.157	NA	0.235	-0.387
2002	-0.0137	-0.0342	0.0335	0.176	0.102	NA	0.245
2003	0.18	0.179	0.0718	0.0733	0.0685	0.249	NA
2004	0.054	-0.137	-0.156	-0.182	-0.206	0.0419	-0.414
Index:	Norwegian BT survey, age 1-7, shifted						
power model							
	slope	power					
1	6.58	0.822					
2	7.97	0.617					
3	7.41	0.672					
4	7.41	0.682					
5	8.47	0.519					
6	8.22	0.566					

Table 5.12 (continued)

linear catchability model								
	mean Q							
7	0.00072							
8	0.000594							
Residuals								
year / age	1	2	3	4	5	6	7	8
1982	-0.469	0.451	0.0736	0.0445	0.391	0.0851	0.671	NA
1983	0.36	0.964	0.291	-0.0644	0.185	-0.243	-0.502	-0.37
1984	0.775	0.31	1.06	0.119	0.451	0.12	-0.67	0.269
1985	-0.0424	-0.128	-0.177	-0.0916	0.432	0.227	0.15	0.169
1986	0.353	0.181	0.0325	-0.103	NA	NA	NA	NA
1987	-0.313	0.202	0.217	0.132	0.00506	0.284	NA	NA
1988	-0.451	0.457	0.251	0.17	0.00672	0.278	0.281	NA
1989	-0.468	-0.198	-0.147	-0.0991	0.0413	0.113	1.63	NA
1990	0.427	-0.15	-0.16	0.21	0.119	-0.265	1.01	NA
1991	0.377	0.0695	-0.218	-0.281	0.0389	-0.142	0.292	1.03
1992	0.112	-0.232	-0.0024	-0.345	-0.0654	0.113	-0.536	-0.452
1993	0.11	0.0575	-0.152	-0.0659	-0.183	-0.149	-0.644	-0.203
1994	-0.346	-0.0216	-0.0187	0.00899	0.115	0.122	NA	0.224
1995	-0.165	-0.17	0.181	0.263	-0.0035	0.183	0.837	NA
1996	-0.228	-0.0054	0.0807	0.108	0.052	-0.004	1.4	-0.044
1997	NA	0.0617	-0.0384	0.161	-0.0441	-0.0709	1.02	0.921
1998	-0.492	NA	-0.0681	-0.204	0.0745	-0.0993	0.38	0.187
1999	0.137	-0.107	NA	0.064	0.00748	0.0131	-0.321	0.458
2000	0.115	0.0292	-0.016	NA	0.00721	-0.176	-1.27	-0.641
2001	0.136	0.051	-0.0408	-0.0184	NA	0.0492	-0.761	NA
2002	-0.00442	0.134	0.00327	-0.175	-0.0541	NA	-0.53	-1.27
2003	0.142	-0.0056	0.0306	-0.0403	-0.0551	0.232	NA	0.304
2004	0.253	0.0522	0.133	0.172	0.0262	-0.0921	-0.315	NA

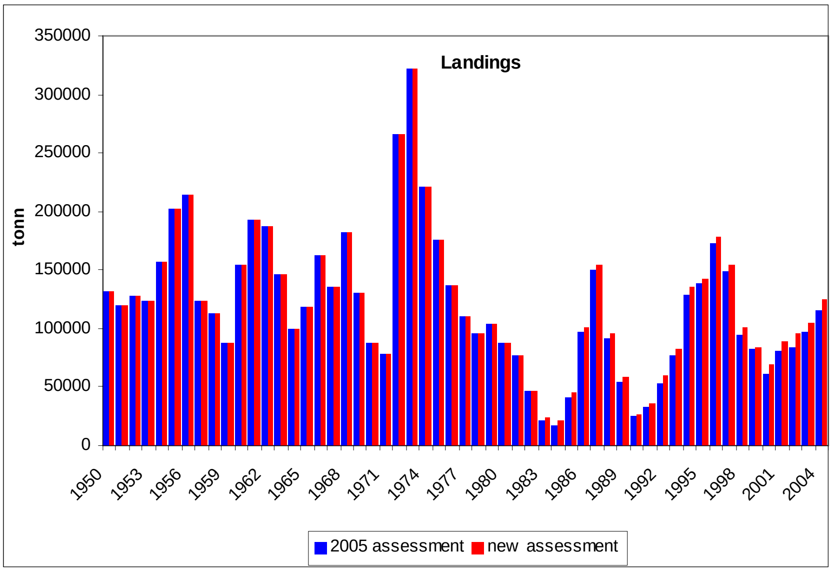


Figure 5.1 Comparison of revised and AFWG 2005 landings of Northeast Arctic Haddock

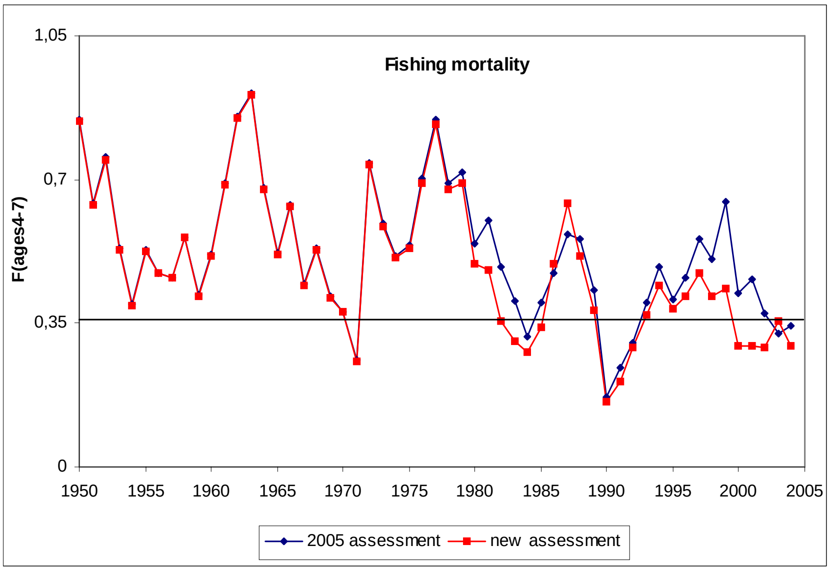


Figure 5.2 Comparison of fishing mortalities using revised data and AFWG 2005 fishing mortalities

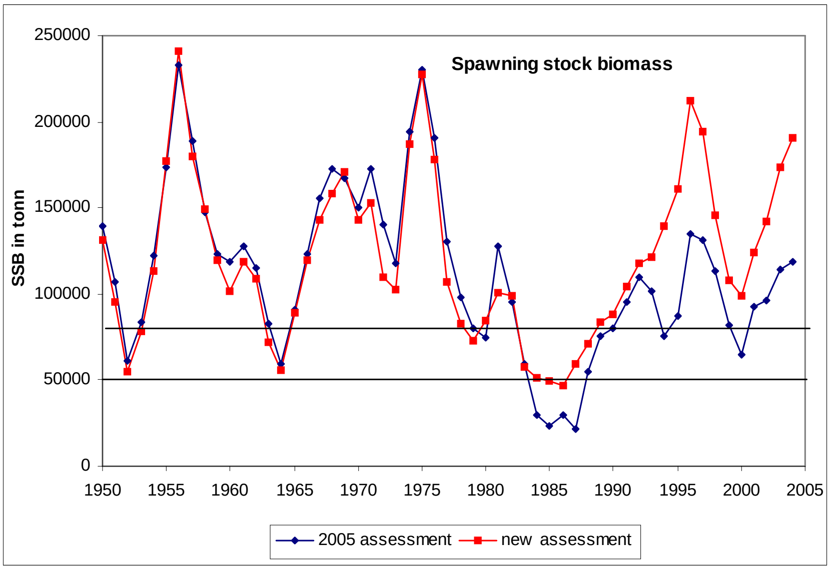


Figure 5.3 Comparison of spawning stock biomass estimates from the revised assessment and AFWG 2005

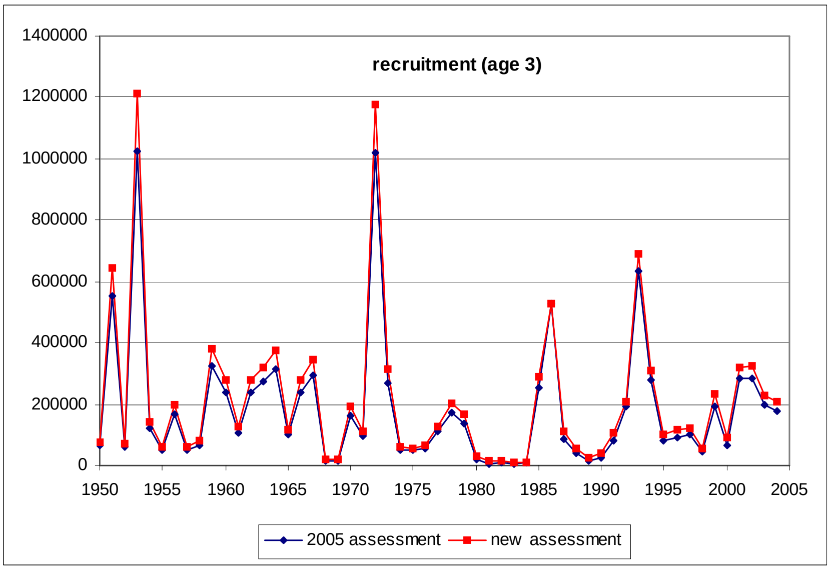


Figure 5.4 Comparison of recruitment estimates from the revised assessment and AFWG 2005

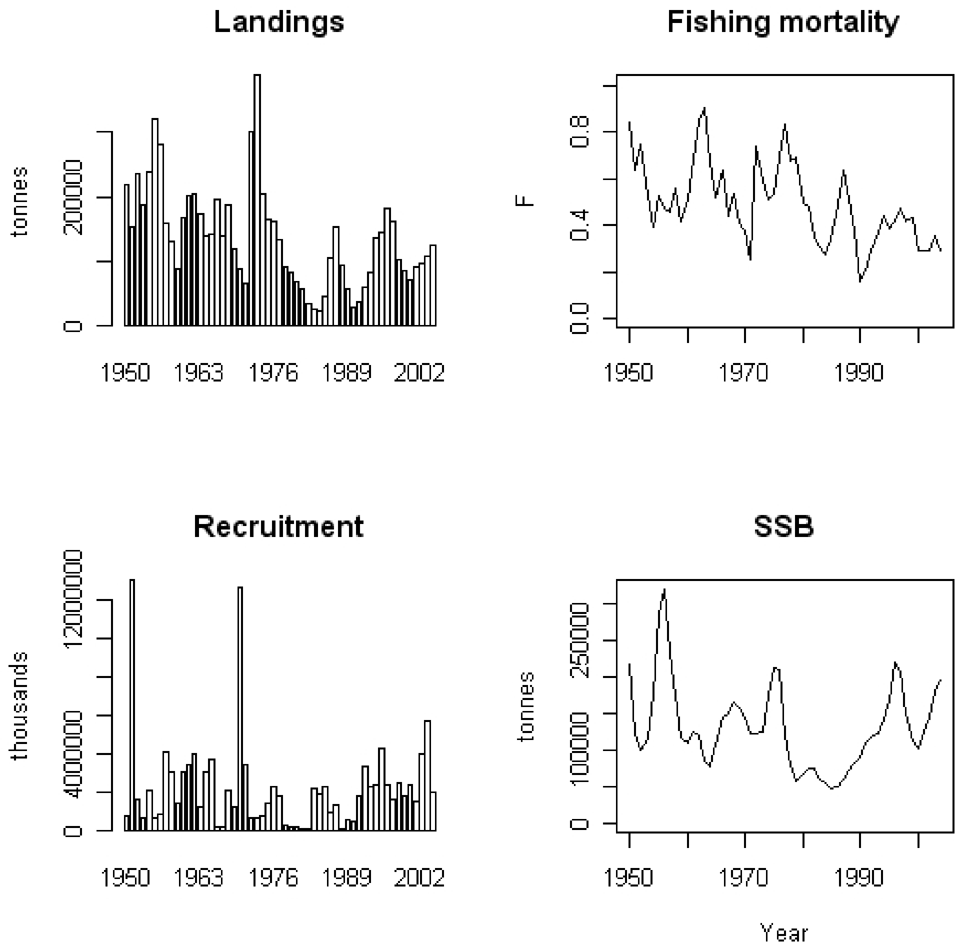


Figure 5.5 Time series of Landings, F, Recruitment and SSB.

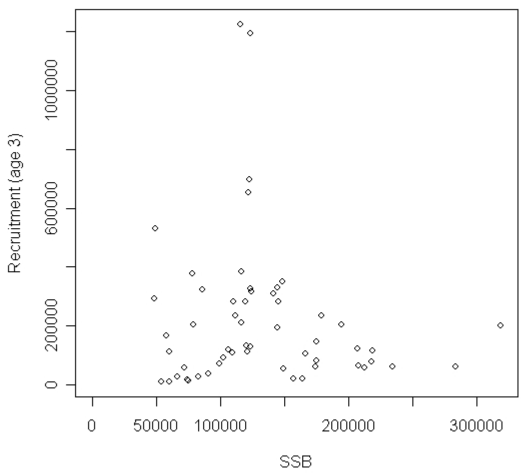


Figure 5.6 SSB - Recruitment (age 3) plot

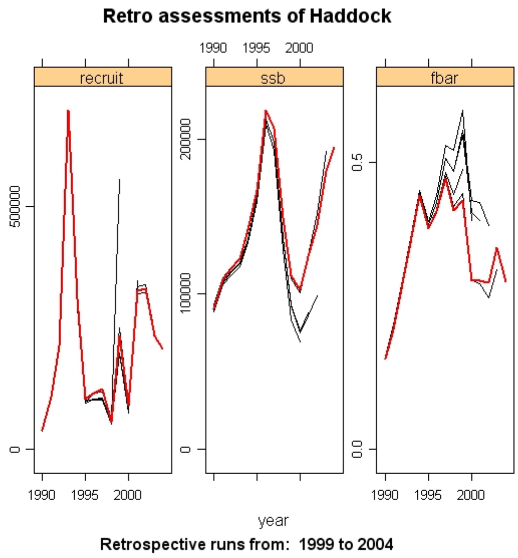


Figure 5.7 Retrospective plots 1990–2004

6 Revision of reference points

6.1 Biomass reference points

ICES established the reference points for NEA haddock in 1998. The currently used values and rationality for RP estimates are given in tables below (from ICES, 2005b).

	ICES considers that:	ICES proposed that:
Precautionary Approach reference points	B_{lim} is 50 000 t	B_{pa} be set at 80 000 t
	F_{lim} is 0.49	F_{pa} is set at 0.35
Target reference points	NA	NA

Technical basis

$\mathbf{B}_{lim}$: only poor recruitment has been observed from 4 years of SSB < 50 000 t and all moderate or large year classes have been produced at higher SSB.	$\mathbf{B}_{pa}$ = $\mathbf{B}_{lim}$ * 1.67.
$\mathbf{F}_{lim}$ = median value of $\mathbf{F}_{loss}$.	$\mathbf{F}_{pa}$ = $\mathbf{F}_{med}$. The stock has sustained higher fishing mortality for most of the period after 1950; however, low SSB has often been the result.

During the current meeting the biological data, catch at age numbers and landings data were revised. Thus it is necessary to re-evaluate the current values of reference points in the light of the revised SSB and recruitment time-series of NEA haddock.

6.1.1 B_{lim}

In the ICES implementation of the precautionary approach (PA), which seeks to prevent stocks being harmed seriously due to recruitment over-fishing, B_{lim} has an intrinsic biological basis since for a biomass below B_{lim} there is a substantial increase in the probability of obtaining poor year-classes. In practice the value of B_{lim} is derived from historical stock-recruitment data, as the point below which there is evidence that recruitment becomes impaired. The word impaired means that that recruitment becomes systematically reduced as biomass declines below a certain point due to the effect of fishing.

The segmented regression function was used in an attempt to estimate B_{lim}. The analysis has been done for two time periods. The model was fitted to the data from the NEA haddock assessment made during this meeting for SSB-recruitment at age 3 and for the year-classes 1950–1998 and 1980–1998.

The bootstrap procedure has been used to test significance of the segmented regression model against two other stock-recruitment models.

6.1.2 Description of the bootstrap algorithm used for the segmented regression

The alternative hypothesis

– H_1: The recruitment follows a segmented regression model

was tested against two null hypotheses:

– H_{0C}: The recruitment is constant

– H_{0S}: The recruitment has a constant slope and zero intercept (R = b SSB)

A traditional approach would use the null hypothesis that recruitment is nothing else than noise with a constant mean ($E(R)=\mu$). There are strong reasons not to choose this as the null hypothesis when estimating stock and recruitment relationships. The recruitment at zero spawning stock is zero. And it is obvious that the larger the number of eggs produced the larger is the potential recruitment. And with this choice of null hypothesis the questions asked would be like: "How high must the spawning stock be before recruitment does not increase anymore and levels out?"

H_1 was tested against the null hypothesis using the following bootstrap algorithm:

i) fit the segmented regression model to the data and calculate the squared sum of residuals SSQ_{SR}

ii) fit the model corresponding to the null hypothesis and calculate the squared sum of residuals SSQ_C

iii) calculate $F_{OBS} = (N-2)\ (SSQ_C - SSQ_{SR}) / SSQ_{SR}$

iv) for 100 bootstrap iterations

a) generate $R_i^{*,k} = \hat{R}_i + e_i^{*,k}$ where $\hat{R}_i$ is the recruitment in year *i* predicted from the "null" model and $e_i^{*,k}$ is drawn with replacement from the residuals

b) Fit the segmented regression model and the "null" model to $\{R_i^*\}$ and calculate $F_{OBS}^{*,k} = \max\left\{0,(N-2)\ (SSQ_C^{*,k} - SSQ_{SR}^{*,k}) / SSQ_{SR}^{*,k}\right\}$

v) Calculate the p-value as the fraction of $F_{OBS}^{*,k}$ that is larger than the original F_{OBS}

In Figure 6.1 and 6.2 $F_{OBS}^{*,k}$ is plotted

6.1.3 Results of re-estimation and diagnostics

Parameter values, including the change-point (**S*** = $\mathbf{B}_{lim}$), slope in the origin ($\hat{\alpha}$) and recruitment plateau (**R***), were computed and are presented in the following table:

Left part: Results from fitting of the segmented regression model. **S*,** $\hat{\alpha}$ and **R*** indicate change-point, slope, and recruitment plateau, respectively. Middle part: Results from a bootstrap test of H_0: R=constant against H_1: the relation between R and SSB is described by the segmented regression model. Right part: Results from a bootstrap test of H_0: R = a * SSB against H_1: the relation between R and SSB is described by the segmented regression model. For the F and p-values see the paragraph about the bootstrap algorithm for details.

	Model			**H0: R=Constant**			**H0: R = a * SSB**		
Time period	**S***	$\hat{\alpha}$	**R***	**Resid df**	**F-value**	**p-value**	**Resid df**	**F-value**	**p-value**
1980-1998	87889	1,40	123047	18	0,67	0,23	18	0,84	0,28
1950-1998	227412	1,08	245416	48	3,27	0,06	48	-0,01	0,62

The estimates of the spawning stock biomass for which recruitment is impaired are 88 and 227 thousand tonnes for periods 1980–1998 and 1950–1998 correspondently, using the algorithm of Julious (2001). Nevertheless, the segmented regression model does not fit the data significantly better than the constant model or the zero-intercept regression model using a 5% significance level.

The fits of the segmented regression model to the data and diagnostic plots are shown in Figures 6.1 and 6.2.

The results of estimation for period 1980–1998 are very sensitive to the data for the most recent years (Figure 6.1 e, f, g) and indicate gradually more favourable recruitment conditions over some time. The breakpoint estimation for period 1950–1998 is stable. Strongly varying natural mortality together with fluctuations in maturity makes it difficult to compare the dynamics of the stock after 1980 to the stock previous to 1980 where these values are assumed constant.

6.1.4 B_{loss}

Due to changes in biological data and catch-at-age made during this meeting, the estimates of SSB and R are changed. The lowest observed biomass (SSB at 1986) is now 46 thousand tonnes, which is much higher than the AFWG-2005 assessment made before revision of the data (27 thousand tonnes in year 1985). The average value of the 3 lowest spawning biomasses (1984, 1985, 1986) is very close to 49 thousand tonnes.

6.2 Fishing mortality reference points

Not discussed or revised

6.3 Candidate target fishing mortalities

Not discussed in detail. ACFM stated in their report (ICES, 2005b) that "candidates for reference points which are consistent with taking high long-term yields and achieving a low risk of depleting the productive potential of the stock may be identified in the range of $\mathbf{F}_{0.1}$-$\mathbf{F}_{max}$ " (F between 0.202 and 0.321). Periods of reduced individual growth of NEA Haddock seem to be linked with stock size. The evaluation in Section 7 uses density dependent weight at age (see Section 7.3.2). The historic time series of NEA Haddock represents long periods with high fishing mortalities and the observed growth may not reflect the productivity of the stock at larger stock sizes and yield will typically be maximised at slightly higher fishing mortalities.

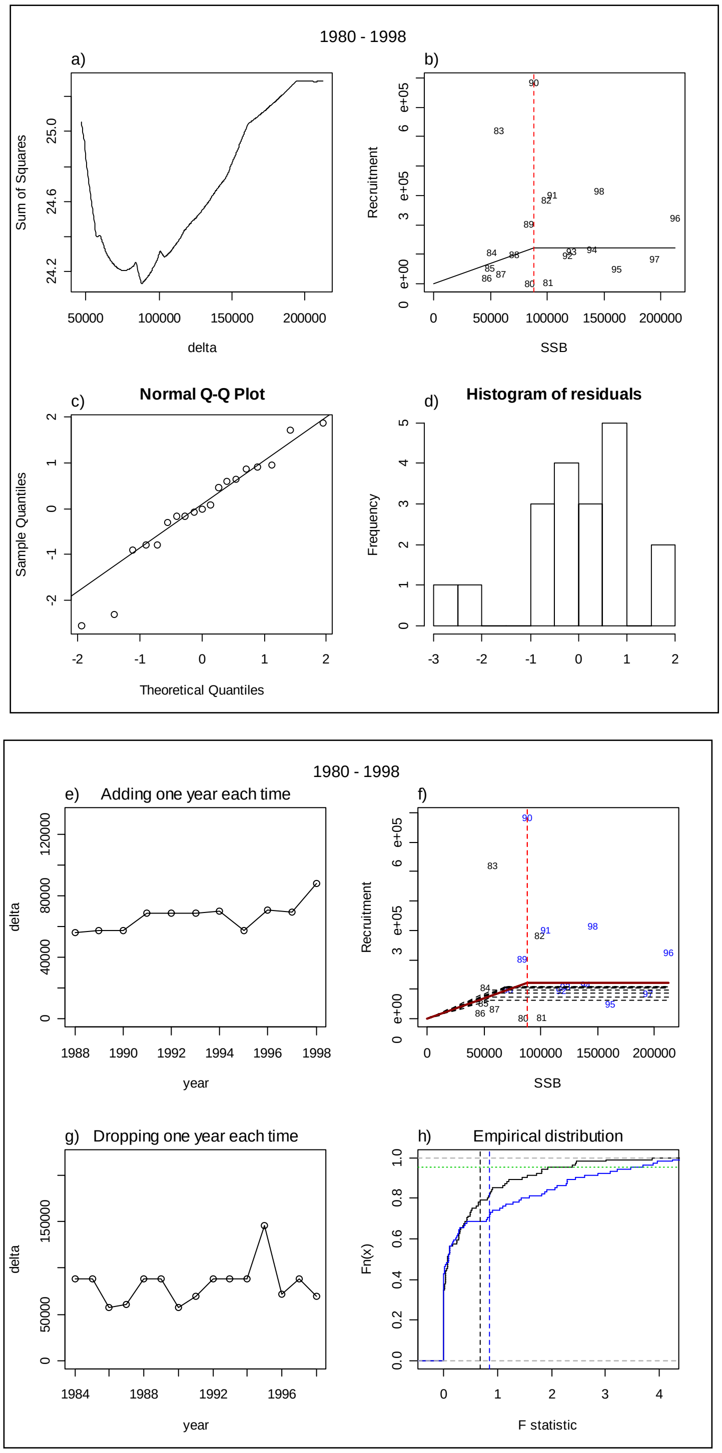


Figure 6.1. Results (a-d) and diagnostics (e-h) from a fit of the segmented regression model to data from 1980–1998. a) Residual sum of squares as a function of the change-point delta; b): stock-recruitment pairs identified by year class; the solid line shows the estimated model, the vertical dotted line indicates the estimated change-point; c) normal plot of residuals; d) histogram of residuals; e) the estimated change-points when adding one year at the time, starting with all years before 1988 excluded; f) same as b) but dotted lines indicate the change-point model estimates obtained by adding one year at the time. The years 1988–1998 are shown in blue; g) the estimated change-points when excluding one year at the time; h) solid lines: empirical distribution of F-values from the 100 bootstrap replicates (see the paragraph about the bootstrap algorithm for details), dotted lines: the F-value for the real data, black: H_0: constant recruitment, blue: H_0: R=a*SSB. ($F = (n-2)\ (RSS_{H0} - RSS_{H1}) / RSS_{H1}$).

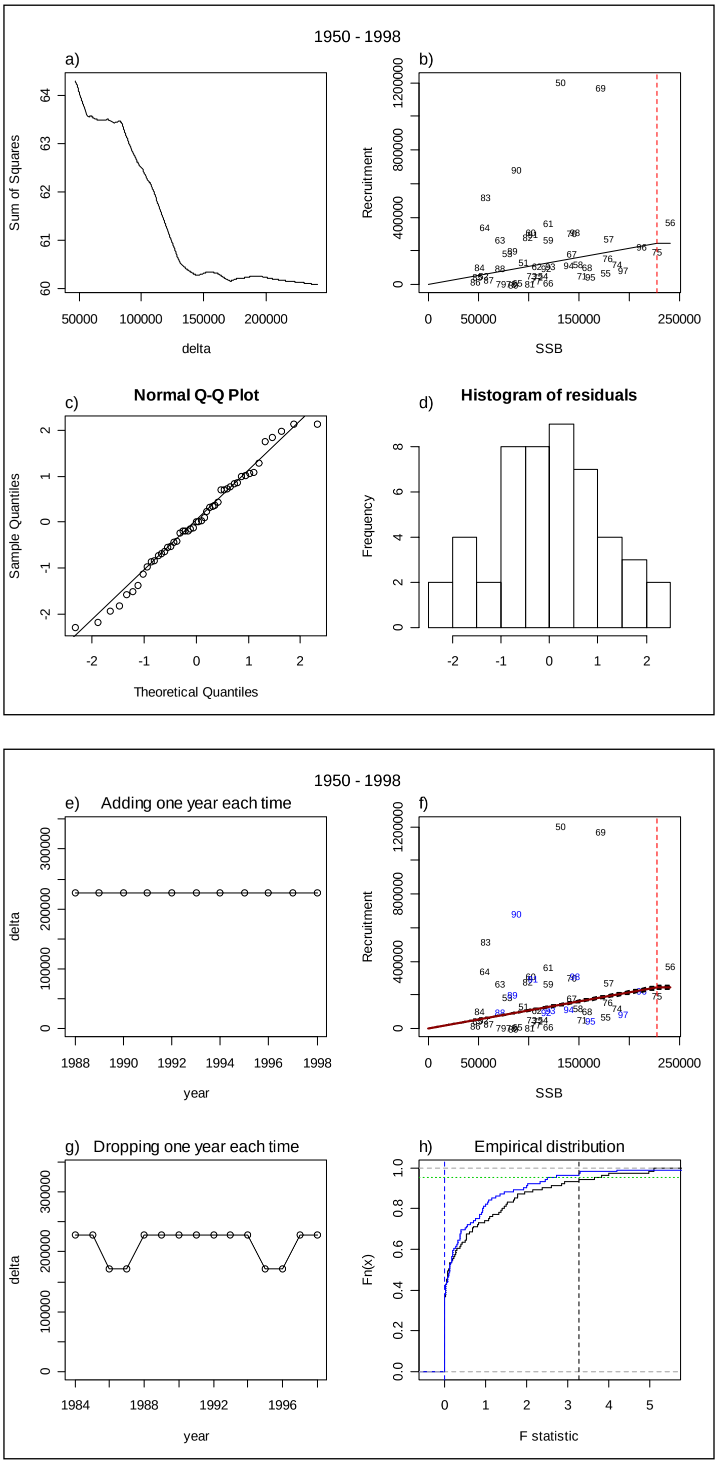


Figure 6.2. Results (a-d) and diagnostics (e-h) from a fit of the segmented regression model to data from 1950–1998. a) Residual sum of squares as a function of the change-point delta; b): stock-recruitment pairs identified by year class; the solid line shows the estimated model, the vertical dotted line indicates the estimated change-point; c) normal plot of residuals; d) histogram of residuals; e) the estimated change-points when adding one year at the time, starting with all years before 1988 excluded; f) same as b) but dotted lines indicate the change-point model estimates obtained by adding one year at the time. The years 1988–1998 are shown in blue; g) the estimated change-points when excluding one year at the time; h) solid lines: empirical distribution of F-values from the 100 bootstrap replicates (see the paragraph about the bootstrap algorithm for details), dotted lines: the F-value for the real data, black: H_0: constant recruitment, blue: H_0: R=a*SSB. (F = (n-2) (RSS_{H0} – RSS_{H1}) / RSS_{H1}).

7 Evaluation of the agreed HCR

7.1 The HCR rule

7.1.1 Description

The 33rd meeting of the Joint Russian-Norwegian Fisheries Commission (JRNC) in November 2004 decided on a harvest rule for cod and haddock. A translation of this can be found in Section 3 of this report. The rule can be summarised as follows:

- TAC is set to the average of the predicted catches in the TAC year and the 2 following years using a fishing mortality $F_{target}=F_{pa}=0.35$.
- The TAC should not be changed with more than 25% relative to the previous years' TAC.
- The limit of maximum 25% annual change in TAC shall not be used if the SSB falls below B_{pa} in the current year or any of the 3 prediction years.
- If the SSB falls below B_{pa} the fishing mortality should be reduced linearly from F_{pa} at $SSB=B_{pa}$ down to F=0 at SSB=0.

The rationale for choosing a 3-year prediction period is to make the catch level more stable.

7.1.2 Interpretation of management objectives

The agreement is clear in stating that one of the objectives is to achieve high long-term yield. There can be some variations in the interpretation of this objective, and one that springs to mind is “not too far from maximum long-term yield”.

The second objective is to achieve a degree of year-to-year stability in TAC. A stability criterion is a direct part of the rule itself.

Together with these two management objectives, the following is expressed: “the strategies ... should take into account ... full utilization of all available information on stock development”. This deals with the quality of the assessments of the stock and the performance quality of the harvest control rule.

An underlying objective is that the HCR as a tool for managing the stock should perform in accordance with the precautionary approach. The information in the referred agreement is only reflecting a part of the management objectives for this stock. Both parties have agreed on specific management measures designed to protect juvenile haddock.

The workshop responds to all objectives expressed by the Commission.

7.1.3 Management measures

The management system is TAC based with some additional measures. One of the more important ones is temporary closures in both time and space, which are used extensively. These closures are based on monitoring and sampling from the fishing activity using a certain proportion of the catch below the minimum landing size as criteria for closure. Few attempts have been made to quantify the effect of these closures due to problems with the estimation of reallocation of effort and how the availability of other fishing opportunities are effecting fishermen/vessel behaviour. The general mesh size regulation for trawl in the Barents Sea implies the use of codends with a mesh size of 125/135 mm. There is an additional regulation requiring that a rigid sorting grid (55 mm) is mounted in the front of the codend.

7.1.4 Limitations in the current evaluation

The evaluation is to a large extent based on simulations. All simulations have their limitations and shortcomings in how well they can mimic a fisheries system and these limitations influence the ability to make conclusions. The perception of the dynamics of the stock may be flawed. Such flaws can be related to incomplete knowledge of the system, biased information being used or the simulation itself lacking the degree of complexity needed (see also ICES, 2006, Section 7). The following list represents important factors, shortcomings or weaknesses not taken into account in the simulations made at this workshop:

1) Discarding and high grading is known to occur in fisheries that catch NEA haddock (ICES, 2005a, AFWG report). There is a general discard ban in all the fisheries that catch NEA Haddock. There is very little information available that can be used to estimate the extent of discarding. Discarding may be a factor that reduces the ability of the simulation to mimic the "true" dynamics of fisheries system. All conclusions drawn from the simulations described in this report assumes none or negligible discarding/high-grading.

2) Not all landings of NEA Haddock are recorded. As for NEA cod (ICES, 2005a, AFWG report) unreported landings may (at least for some recent years) form a large part of the catches. The consequences of such a degree of implementation error (transshipping of cod and haddock) have not been a part of the simulations. All conclusions drawn are based on the assumption that the harvest control rule is implemented without such errors.

3) The spasmodic recruitment dynamics of NEA haddock is difficult to simulate (as for other haddock stocks). There is no clear SR-relationship for this stock and this makes it difficult to simulate the potential effect the current fishing has on future yields (only weak signs of reduced recruitment at low spawning stock levels). More details on the simulation of recruitment can be found in Section 7.2.1.

7.1.5 Methodology for evaluation of harvest control rules

Evaluation of HCRs is usually done using simulation models for the population(s) in question. The scope, nature and quality standards of simulation models that may be used in order to evaluate HCRs are discussed e.g. by Skagen *et al.* (2003) and described by SGMAS (ICES, 2005c). SGMAS (Section 4.4) also gives guidelines for evaluation of management strategies.

Important issues for evaluation of harvest control rules are:

a) Choice of population model

b) Inclusion of uncertainty in population model

c) Use of long-term and/or medium-term simulations

d) Choice of initial values for simulations

e) Choice of harvest control rules for use in the evaluation (constant F rules, how to reduce F when $SSB<B_{pa}$, limit on year-to-year variation in catch etc.)

f) Performance measures for harvest control rules (yield, stock size, F, probability of $SSB<B_{lim}$, annual variation in catches etc.)

The general modelling approach taken here is the same as described by Skagen *et al.* (2003).

Considering various tools for evaluating harvest control rules mentioned by SGMAS in 2005 (ICES, 2005c), the simulations were carried out using the PROST software for stochastic projections (Åsnes, 2005). PROST was especially developed for this purpose because existing software for harvest control rule simulations such as WGMTERM, STPR and CS5 do not incorporate the 3-year averaging process (hereafter called the '3-year-average-rule') for setting TAC given by the agreed decision rule. However, PROST is intended as a general tool for stochastic projections.

7.2 PROST simulations

7.2.1 Model settings

7.2.1.1 Population model used

For cod, a biologically detailed population model for cod was used in the evaluation (Bogstad *et al*., 2004). A similar approach was taken for haddock. The chosen population model was:

a) Segmented regression spawning stock-recruitment model, including uncertainty.

b) Weight at age in stock dependent on total stock biomass in the previous year

c) Weight at age in catch is a function of weight at age in stock

d) Maturation at age is a function of weight at age in the stock.

e) Natural mortality at age includes predation mortality by cod, average values for the period 1984-2004 are used.

f) Exploitation pattern: 2002-2004 average used for all years.

g) Implementation of catch: First, the catch at age is calculated from the perceived stock using the fishing mortality derived from the harvest control rule and the given exploitation pattern. This catch at age is then applied to the actual stock.

h) No uncertainty in weight at age, maturity at age or natural mortality at age

The details are given in Section 7.2.1.2-7.2.1.6

7.2.1.2 Stock-recruitment relationship

Possible choices for the stock-recruitment relationship include the segmented regression approach, Beverton/Holt and Ricker. The segmented regression approach with a stochastic term (log-normally distributed) was chosen. We thus look for a stock-recruitment relationship of the form shown in Eq. (1):

$$R_3(year+3) = f(SSB(year))e^{\varepsilon} \qquad (1)$$

where $f(SSB) = \min(\frac{\alpha}{\beta}SSB, \alpha)$ and $\varepsilon = N(0,\sigma)$

To determine the stochastic term ε in equation (1), the approach outlined by Skagen and Aglen (2002) was used. They suggested 3 quality criteria for stochastic stock-recruitment functions:

1) Independence between residuals and SSB

2) Probability coverage

3) The recruitment estimates should be unbiased.

2) is a control that the distribution assumed for the residuals is adequate, while 3) may be used as an additional constraint when finding the parameters of the stock-recruitment function.

Assuming that each of the historic residuals is equally likely, the rank of each of them, divided by the number of observed residuals, gives the empirical cumulated probability of the historical residuals. On the other hand, according to the model that is assumed for the residuals in the prediction, there corresponds a cumulated probability for the value of each observed residual. Each of these model probabilities should be close to the empirical cumulated probability of the same historic residual. The Kolmogorov goodness of fit test is based on this reasoning, and the Kolmogorov test statistic can be derived directly from the pairs of modelled and observed values.

The fit was done using Solver in Excel spreadsheets described by Skagen and Aglen (2002). A constraint on the sum of the difference between modelled and observed recruitments being zero was applied. α = 160 000 t, β = 145 000 t and σ =1.118 gave the best fit to the data. The model explained 25 % of the variation in recruitment. Figure 7.1 shows the residuals vs. SSB. The residuals do not seem to be correlated with SSB.

Figure 7.2 and 7.3 show the probability coverage and observed vs. modelled recruitment for this distribution. The fit seems to be rather satisfactory.

The final test in any case is to take the distribution (or at least the standard percentiles) of recruitments from a long-term prediction and compare with the historic recruitments generated by similar levels of SSB.

7.2.1.3 Weight at age in the stock

We have used the time series from 1980 onwards (stock weights in 1980–2004 vs. total stock biomass in 1979–2003) to fit a density-dependent model for weight at age (kg) in the stock $ws_{a,y}$ for ages 3-7. The model is of the form

$$ws_{a,y} = \alpha_a TSB_{y-1} + \beta_a \qquad (2)$$

where TSB_y is the total stock biomass (million tonnes) in year y, a is age and α_a and β_a are constants. The parameters in the regressions are given in Table 7.1.

It may also be necessary to truncate the range of possible values of haddock weight, in order to avoid unrealistic values due to extrapolations. We chose to use the highest/lowest observed values of haddock weight at each age as upper/lower bounds in the model.

For age 8 and older haddock the time series average (the weight at age in the stock for the period before 1983) was used.

7.2.1.4 Weight at age in the catch

Weight at age in catch is modelled as a function of weight at age in stock, using equation (3):

$$wc_{a,y} = \alpha_a ws_{a,y} + \beta_a \qquad (3)$$

The values of α_a and β_a for ages 3–7 are given in Table 7.2. The regressions are based on data from 1983–2004, when observations of stock weights at age from surveys are available.

Weight at age in the catch is calculated directly from weight at age in the stock using equation (4). For ages 8 and older weight at age in the catch is set equal to the time series average.

7.2.1.5 Maturity at age

Maturity at age and year $P_{a,y}$ is modeled as a function of weight at age in the stock in the same year, given in equation (4)

$$P_{a,y} = P(ws_{a,y}) = \frac{1}{1+e^{-\lambda_a (ws_{a,y} - w_{50,a})}} \qquad (4)$$

The results of fitting this model for ages 3-9 are shown in Table 7.3. For ages 10 and 11+ P=1.

7.2.1.6 Mortality

The (residual) natural mortality (M) was set to the average value for the period 1984–2004. This mortality includes predation mortality from cod. The values for ages 3–6 are given in Table 7.4. For age 7 and older fish M=0.2 was used.

7.2.1.7 Exploitation pattern

The selection pattern used by AFWG 2005 (ICES, 2005a) in their prognosis (i.e. the 2002–2004 average) was chosen as the default exploitation pattern S(a) (Table 7.5).

Since we allow for variable weight-at-age in our model, it would be appropriate to make a weight-dependent selection curve. Also the effect of incoming strong year classes on the fishing pattern should be investigated.

7.2.1.8 Simulation settings

For each run, 2000 simulations 100 years into the future were made. The average values for the last 80 years of the period were used, in order to avoid the influence of the initial values.

Assessment error was included (CV=0.25 for all age groups, uncorrelated), but not implementation error. The error term in the recruitment function (Eq. (1)) was truncated to be between –2.5 and 2.5.

It was decided to explore a range of values for fishing mortality and limits on yearly variations in TAC, in addition to those given in the harvest control rule. Also, the effect of constant vs. modeled values for weight and maturity were considered.

Runs were made for F=0.25, F=0.35 and F=0.45, as well as for 10%, 25%, 35% and no limit (implemented in PROST as a 100% limit) on year-to-year variations in TAC and with modeled values for weight and maturity at age. Also, the runs with a 25% limit on the year-to-year variations in TAC were made with constant values for weight and maturity at age, giving a total of 15 runs. The '3-year average rule' was used in all cases.

7.2.2 Results

The results of the runs are shown in Table 7.6 and 7.7.

7.2.3 Discussion

Table 7.6 shows that the yield is fairly stable in the range F=0.25 to F=0.45, but F=0.35 always gives a higher yield than the other values.

Table 7.7 shows that the suggested HCR (run 2) seems to be in accordance with the precautionary approach, with very low probability for SSB< B_{lim} (and also B_{pa}). The run with the highest probability of SSB< B_{lim} is run 15 (F=0.45, max 10% year-to year change in TAC and fixed weights/maturities), with 2.6 %). It is also seen that using a max 10% year-to year change in TAC increases the probability of SSB < B_{lim} and B_{pa}, while the difference between using 25%, 35% and no limit is small).

The run with $F_{5\text{-}10}$=0.45, and no limit on maximum year-to-year-change in TAC (run 9) can be used as a reality check. The average value of F for the period 1950–2004 is 0.49, and the average values of total biomass, SSB, landings are 329, 121 and 122 thousand tonnes respectively, while the average recruitment at age 3 is 215 million. The stock sizes and catches from run 9 are fairly close to these historical averages. This indicates that the model performs reasonably well at this level of fishing mortality.

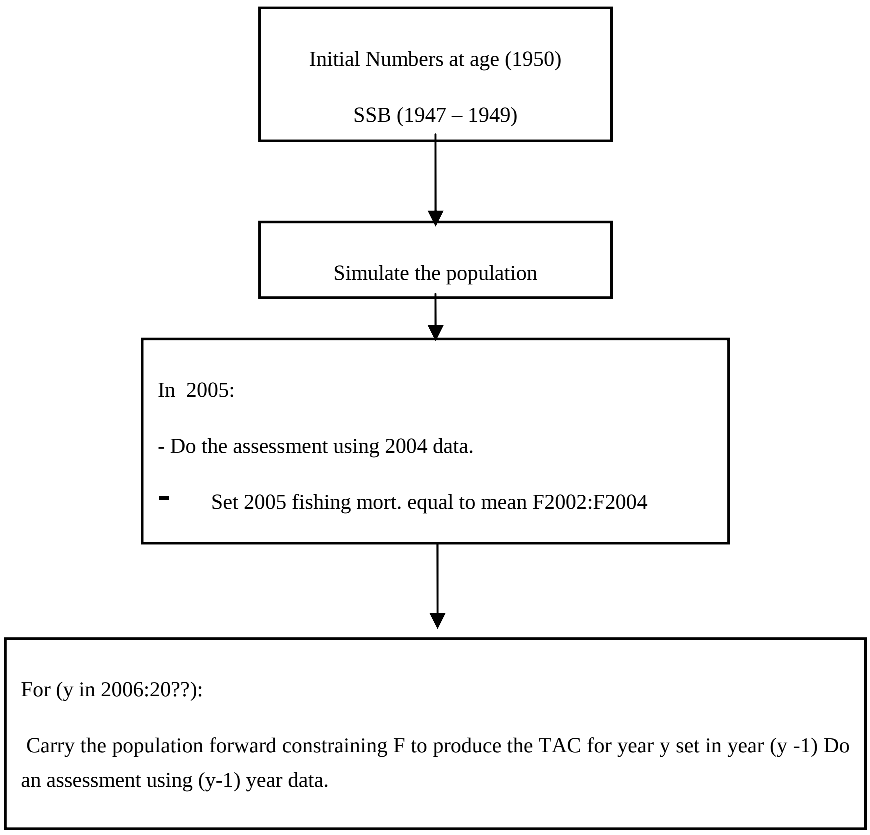
7.2.4 Conclusions

The simulations presented here should be regarded as preliminary, but they do indicate that the proposed HCR seems to be precautionary. The conclusion is given under the limitations presented in Section 7.1.4 and we would like to point out that whether the rule is in accordance with the precautionary approach or not may be irrelevant if the rule is not properly implemented.

7.3 FLR simulations

An attempt was carried out to evaluate the agreed harvest control rule by using the FLR framework. The framework seems very promising with its many possibilities, but to use the evaluation software was too demanding to accomplish what was intended in such a short time.

OPERATING MODEL DIAGRAM



7.3.1 Model settings

The simulation model starts back in time, simulating both the real stock and the assessment of the stock. An assessment is thus carried out each time step based on simulated input data with observation errors so that it is possible get a measure for assessment uncertainty.

The operating model simulates a population given an initial vector of numbers at age, biological parameters (natural mortality at age or natural mortality distribution parameters (lognormal or uniform distribution), weight-at-age, maturity-at-age), a stock-recruitment relationship, and a catch-at-age matrix or a fishing mortality at age matrix obtained from an assessment model.

Variability around stock-recruitment relationship can be introduced using lognormal random numbers or bootstrapping. In the first option a random number is drawn from a lognormal distribution and it is multiplied to the predicted recruitment. The standard error in log scale of the lognormal distribution has to be given as input data. In the second option an error is added to the predicted recruitment. This error is obtained by sampling from the residuals of a stock-recruitment fit.

To carry the population forward the operating model uses the usual catch and survival equations combined with the chosen stock-recruitment relationship. In the historic part of the operating model the catches are obtained by means of fishing mortality, and this fishing mortality is obtained from the input data or by conditioning it to produce the input catch-at-age matrix.

Abundance indices are also simulated using a 'qmodel' or 'power model'. For this purpose the parameters for this models has to be given as input data. For 'qmodel' a catchability-at-age vector and for 'power model' vectors at age for α and β are needed. To account for observation error a multiplicative lognormal error can be introduced in the indices.

An observation error can also be introduced in the catch-at-age matrix using a multinomial distribution.

In the last year of the historic data, 2004 in the examples, an XSA assessment is carried out using the simulated catch-at-age matrix and abundance indices. Using the estimated stock numbers and fishing mortality at age, assuming that the fishing mortality of the assessment year, 2005 in the example, has been equal to the mean fishing mortality of last three years, 2001–2003, and using the agreed Harvest Control Law, a TAC is simulated for 2006. For 2005 and onwards, the projection part, the population is carried forward using the usual catch and survival equations and the chosen stock-recruitment relationship. The fishing mortality in the projections for each year is the one corresponding to the TAC estimated doing an assessment in each year and the harvest control law.

7.3.2 Results

During the WKHAD some initial trials have been done with the operating model. The main problem in simulating the haddock population is the stock-recruitment relationship. Three different stock-recruitment relationships were used, the Ricker model, Beverton and Holt model and a pseudo Ricker-model designed to account for the high recruitments observed in some of the years of the historic data.

Description of Pseudo-Ricker model

The pseudo-Ricker model is a random stock-recruitment simulator, specially built to mimic the high recruitments observed in the historic recruitment data. Besides the parameters of the usual Ricker model, the pseudo-Ricker model has r two additional parameters, B0 which is a threshold spawning stock biomass and *p* that is the probability of obtaining a high recruitment when the spawning stock biomass is above the threshold biomass B0. First we take the observed high recruitment values. In each step (year) of the operating model we act as follows:

- If the SSB is higher than B0:

    - Draw a random number from a binomial distribution with probability '*p*' (low).

        - If the random number is equal to one (success), draw a recruitment from the set of the observed high recruitments and set this year recruitment equal to the drawn recruitment.

        - Else calculate the recruitment using the normal Ricker model.

- If the SSB is lower than B0, calculate the recruitment using the Ricker model.

The same can be done using other kinds of recruitment model, Beverton and Holt, segmented regression etc. Simulating the recruitment in this way makes the probability of getting high recruitments similar to that observed in the assessment.

Beverton-Holt recruitment

The Beverton-Holt recruitment relationship produced by the FLR-packages was obviously flawed so that it could not be used. (All the observed points were below the curve).

Ricker Stock-Recruitment simulation performance

A Ricker stock-recruitment relationship was used in a simulation with the old data, that is, the data used in last year's assessment before the revision. A Ricker stock-recruitment relationship was estimated using the stock numbers estimated by the FLXSA. The recruitment levels in the simulations never reached the high recruitment values observed by the working group, so it seems that the simulated stock can not hold up the observed fishing mortality and with the current HCR the simulated haddock stock extinguish in around ten years.

A simulation with the Pseudo-Ricker model was carried out which improved the performance. However the harvest control rule had not been correctly implemented in the simulations so that the performance was still not satisfactory.

The old data was exchanged with the revised data. This caused a number of problems, the easiest ones to resolve explained by the fact that the age range was changed in the stock data. The more serious problems made us conclude that the simulations were too shaky to put confidence in. In addition it was obvious from the results that the harvest control rule was still not correctly implemented although a correction was made after the evaluation runs with the old data. We did not have time to look into this as we concentrated on the more serious problems.

7.3.3 Conclusions

In spite of the problems, we do believe that the problems will be resolved before the Arctic Working Group meeting in April this year. The FLR framework looks promising.

Table 7.1. Parameters in regression for density-dependent weight at age in the stock, and minimum, maximum and average values.

age	α_a	β_a	R^2	min observed weight	max observed weight
3	-0.30	0.43	0.19	0.25	0.59
4	-0.81	0.89	0.45	0.47	1.04
5	-1.30	1.41	0.57	0.75	1.57
6	-1.40	1.89	0.45	1.08	2.12
7	-1.20	2.27	0.21	1.44	2.67

Table 7.2. Parameters in regression for weight at age in the catch vs. weight at age in the stock.

age	α_a	β_a	R^2	min observed weight	max observed weight
3	1.44	0.30	0.25	0.50	1.22
4	1.40	0.20	0.70	0.77	1.63
5	1.08	0.27	0.80	1.00	2.04
6	1.14	0.04	0.81	1.18	2.85
7	0.66	0.66	0.46	1.30	2.85

Table 7.3. Parameters in model for maturity at age vs. weight at age in the stock.

age	λ_a	$W_{50,a}$
3	2.707	2.072
4	1.347	2.323
5	1.261	1.657
6	1.231	0.989
7	1.026	0.163
8	0.564	-2.690
9	0.464	-5.745

Table 7.4. Natural mortality used.

Age	3	4	5	6
Mortality	0.3371	0.2309	0.2175	0.2023

Table 7.5. Exploitation pattern used.

Age	3	4	5	6	7	8	9	10	11+
Selection	0.0241	0.1520	0.2951	0.5050	0.4400	0.4560	0.3178	0.4720	0.4720

Table 7.6. Results of long-term stochastic simulations – stock biomass, recruitment and yield. Median values for the 2000 simulations performed for each run

Run no	F	%	Weight/ maturity	F	F distort.	Catch (1000 t)	SSB (1000 t)	TSB (1000 t)	Recruits (millions) Age 3
1	0.25	25	Modelled	0.25	0.25	132	343	617	249
2	0.35	25	Modelled	0.36	0.36	139	240	507	247
3	0.45	25	Modelled	0.46	0.47	139	175	425	231
4	0.25	35	Modelled	0.25	0.26	131	340	615	249
5	0.35	35	Modelled	0.36	0.37	140	237	504	247
6	0.45	35	Modelled	0.47	0.48	138	173	419	229
7	0.25	100	Modelled	0.26	0.26	132	339	613	250
8	0.35	100	Modelled	0.36	0.37	140	235	500	246
9	0.45	100	Modelled	0.47	0.48	137	171	416	227
10	0.25	10	Modelled	0.25	0.25	130	361	640	248
11	0.35	10	Modelled	0.36	0.36	136	249	514	240
12	0.45	10	Modelled	0.48	0.48	132	170	411	217
13	0.25	25	Fixed	0.25	0.25	150	361	752	250
14	0.35	25	Fixed	0.36	0.36	153	237	593	239
15	0.45	25	Fixed	0.45	0.46	136	151	445	206

Table 7.7. Results of long-term stochastic simulations. Probabilities of SSB < B_{lim} and B_{pa} and overview of how often different parts of HCR is applied. Mean values for the 2000 simulations performed for each run.

Run no	F	%	Weight/ maturity	% years SSB < Blim	% years SSB < Bpa	% of years where various parts of HCR decide TAC			
						SSB > Bpa			SSB < Bpa
						not restricted	restricted by % increase	restricted by % decrease	
1	0.25	25	Modelled	0.0	0.0	83.9	11.2	4.8	0.0
2	0.35	25	Modelled	0.0	0.1	80.4	13.1	6.3	0.2
3	0.45	25	Modelled	0.1	3.3	75.6	12.6	7.8	3.9
4	0.25	35	Modelled	0.0	0.0	94.7	4.5	0.8	0.0
5	0.35	35	Modelled	0.0	0.2	92.5	5.8	1.3	0.3
6	0.45	35	Modelled	0.1	3.9	87.8	5.9	1.9	4.4
7	0.25	100	Modelled	0.0	0.0	100.0	0.0	0.0	0.0
8	0.35	100	Modelled	0.0	0.4	99.5	0.0	0.0	0.5
9	0.45	100	Modelled	0.2	4.3	95.1	0.0	0.0	4.9
10	0.25	10	Modelled	0.0	0.2	34.3	35.4	30.1	0.3
11	0.35	10	Modelled	0.2	2.1	31.7	35.1	30.9	2.3
12	0.45	10	Modelled	1.0	9.8	31.6	26.7	31.0	10.8
13	0.25	25	Fixed	0.0	0.0	81.2	13.1	5.7	0.0
14	0.35	25	Fixed	0.1	1.7	77.0	13.5	7.6	1.9
15	0.45	25	Fixed	2.6	16.0	65.6	8.4	9.1	17.0

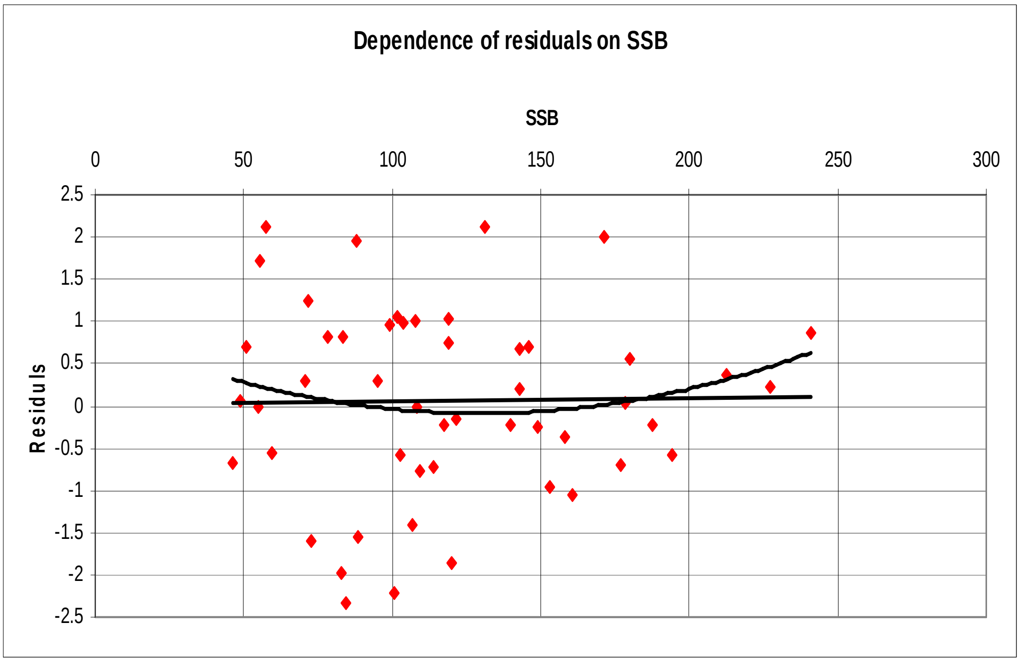


Figure 7.1 Dependence of residuals on SSB

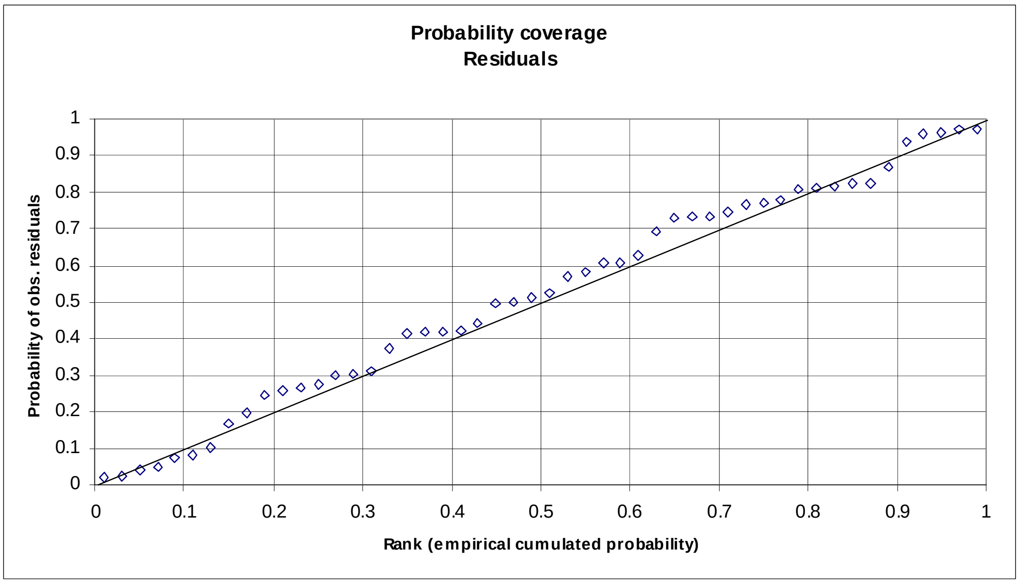


Figure 7.2 Probability coverage for stochastic stock-recruitment function.

Figure 7.3 Observed vs. modelled recruitment for stochastic stock-recruitment function.

8 Discussion

8.1 Revisions made to the input data

The biggest change to the landings data was the inclusion of Norwegian landings from areas south of 67°N. These landings were previously treated as belonging to another stock (Norwegian coastal haddock). The amount of landings added was around 5000 tonnes per year. These additions have been made only back to 1983. The added landings are relatively small compared to the total, but since they consist mostly of older fish, the numbers at age in the revised assessment is increased more than if the age composition had been similar. Figure 5.2 shows that the revised fishing mortality is reduced most in the end of the series.

The estimation of catch composition of Norwegian landings was changed from using traditionally relative frequency derived age-length keys to a Bayesian hierarchical model (Hirst *et al.*, 2004). The old approach used a manual and somewhat subjective approach to "fill" missing cells in the age-length data (samples missing from a quarter/area/gear combination) while the new model estimates these. This is also a source of change that goes back to 1983. The workshop did not have time to look into the details of the impact of this change, but since this together with the change in the landings data are the only changes that have had any impact on the catch at age matrix some insight was gained by comparing the trends in fishing mortalities from the new XSA assessment with the previous. Figure 5.2 shows clearly that even though some of the major trends are similar the levels are quite different in some years.

The maturity at age and weight at age data were also revised and the information from both Russia and Norway was modelled (effectively smoothing "noisy" data). Previous assessment used only Russian maturity data and the revised data are the average of both Norwegian and Russian maturity ogives. The inclusion of the Norwegian maturity data is then an additional source of change in addition to the "smoothing". The impact on the assessment can partly be seen in Figure 5.3, which compares the history of SSB's. The impact previous to 1980 is the result of applying a new average maturity ogive calculated from the revised maturity ogives after 1980 and similarly for the weight at age data. The changes are only minor while the changes in the most recent part of the time series are quite drastic with a general revision upwards of SSB. The SSB estimates for some years have more than doubled. The strong fluctuations in maturity and weight at age observed after 1980 (Figures 4.14 and 4.15) form a large part of the properties of the stock and care must be taken if the whole time series is to be used for the evaluation of stock dynamics (for example the estimation of biomass reference points).

The cyclic behaviour of the growth (see Figures 4.5 and 4.10) is most likely linked to environmental conditions in combination with density dependent effects. How these are linked is not straightforward to resolve and strong fluctuations in natural mortality induced by predation from cod is an important factor in the picture.

8.2 Revisions of reference points

The previous choice of B_{lim} (ICES, 2005b) was justified by: "only poor recruitment has been observed from 4 years of SSB < 50 000 t and all moderate or large year classes have been produced at higher SSB."

The revision of the input data changed the picture (see the SSB – recruitment plots in Figures 6.1 and 6.2). The lowest SSB estimates were revised upwards. The picture is to some extent sensitive to time period chosen (1950–1998 or 1980–1998) and both periods have only a weak increasing trend in recruitment with increasing SSB. This is to be expected as long as the natural mortalities at age 1 and 2 vary as much as indicated by their estimates. Total natural mortality at both age 1 and age 2 varies from 0.8 to 3.9. That corresponds to 44% survival from age 1 to age 3 down to less than 2% survival to age 3. Future work should look in more detail into the fluctuations in natural mortality and investigate whether such estimates of natural mortality is of sufficient quality to allow for using age 1 as recruiting age in a SSB – recruitment relationship.

In establishing a functional relationship between SSB and recruitment the choice of null hypothesis may be essential. In section 6.1.2 and 6.1.3 two different versions of null hypothesis are used. The outcome of establishing a B_{lim} based on properties of a stock-recruitment fit may rely heavily on the choice of null hypothesis. The segmented regression fit was not significantly better than any of the null hypothesis (even though P=0.06 for the segmented fit relative to the whole time series and using constant recruitment as the null hypothesis is significant at the 6% level). Since recruitment is auto correlated in time (especially poor recruitment has a tendency to come in short periods) the inference calculations will be weakened when the autocorrelation is taken into account. This can be explained as recruitment not being driven by SSB size alone, but also by other processes with a varying effect on recruitment over time. Predation from cod would be the most likely candidate.

No effort/analysis was made to reestimate/redefine B_{pa}. One should, however, note that establishing B_{pa} as a safe distance to the limit point should be done using the uncertainty in predictions. Such uncertainty estimates could be made by looking at the historic performance of the assessment and predictions, but can only partly cover the uncertainty introduced by factors like discarding and unreported landings. Such uncertainty estimates is then linked to the question: "How well are we able to predict future reported landings and their composition?"

8.3 Evaluation of the agreed harvest control rule

The limitations to this evaluation are described in Section 7.1.4 and this discussion should be read with these limitations in mind. Discarding, unreported landings and our limited ability to realistically simulate spasmodic recruitment are currently factors that limit the ability to draw conclusions from any simulation.

The target fishing mortality in the HCR is set to F=0.35. Previous yield per recruit analyses indicate similar levels of yield at a rather wide range of fishing mortalities. The workshop set up the simulations to gain insight into 2 aspects:

1) The effect of changing the target F in the HCR (F=0.25, F=0.35 and F=0.45).
2) The effect of different stability criteria and the workshop decided to try out no stability restrictions (presented as 100%), 35% TAC stability from year to year, 25% stability (as in the rule) and 10% TAC stability.

The results of these 12 combinations were presented in Tables 7.6 and 7.7 together with some simulations showing the effect of not including density dependent growth/maturation. With the limitations given in Section 7.1.4 in mind, the range of long term yield shows very little variation (the lowest yield is only 7% lower than highest yield simulated). The results indicate that it is not likely to increase the yield by increasing the current target F, and the simulations also indicate a reduced yield in tonnes at lower fishing mortalities (economic yield is another issue). The simulations also indicate increased costs (reduced yield in tonnes) related to the stability criteria in the cases where no TAC stability criteria showed the least costs (or highest yield). The managers should be aware that for fluctuating stocks a high degree of TAC stability might only be achieved through large variations in effort (or fishing mortality) which again is linked to some costs (keeping the fishing fleet capacity at the level needed to produce the highest fishing mortalities). The simulations using constant growth and maturity showed highest yield at the lowest fishing mortality (F=0.25) and this is to be expected.

The HCR rule is based on a 3-year deterministic prediction and the workshop did not simulate the effect of replacing this with the more traditional 1-year prediction. The errors in predicting future stock sizes is always larger than the assessment error and even more so in a 3 year prediction. The workshop suspects that this introduces more year-to-year variations in the catch forecasts. This may not represent a serious problem because a stability criterion will have a tendency to cancel out the forecast "noise". It is however a major issue if the assessment is biased over a time period. See also Annex 4 Recommendations.

A negative side of using a 3-year prediction in the HCR can occur if the predictions include very strong year classes entering the fishery at the end of the prediction period. This will give an increase in the 3-year average catch at F=0.35 and the TAC in the first year of the prediction (the TAC year) will be increased before the strong year class enters the fishery. The workshop did not look into such details and future simulations should evaluate the risk of the HCR causing "too high" fishing mortalities.

A very positive side of the 3-year prediction occurs when the opposite event of very poor recruitment is predicted. This will lead to a reduction in TAC and fishing mortality before the poor recruitment is having an effect on fishing opportunities.

The previous two paragraphs describe potential positive and negative effects of using a 3-year prediction in the HCR. How large these effects are is related to how well we are able to predict the incoming year classes that far into the future. Assessment working groups will traditionally replace highly uncertain recruitment estimates with some average recruitment number. This is likely to reduce both the positive and negative effects described above. This leads to an interesting question: What is the effect of making the replacement of recruitment estimates with the corresponding average one-sided? That is replacing only recruitment estimates above average with the average and in that way try to keep the positive effect of the 3-year prediction part of the HCR.

9 Conclusions

Input data on catches and biological parameters were revised (Section 4). The Workshop recommends that the revised data and parameters be used in the assessment of NEA haddock. It might also be useful to revise the survey data and look into possible ageing problems.

B_{lim} was the only reference point that was investigated at the workshop. The stock and recruitment relationship was changed so much that the previous rationale could no longer be used. B_{loss} was proposed as a candidate for B_{lim} and the average of the 3 lowest SSB's is close to 50 000 tonnes. Segmented regression was also carried out, but because of the SSB-recruitment relationship this did not result in a clear candidate. A consensus on a B_{lim} was not reached at the workshop.

No effort was made to redefine B_{pa}, but this needs to be done. The workshop thinks that a B_{pa} established by the same procedure as for NEA cod so that prediction uncertainty is included in the calculations is a good candidate. B_{MSY} is a general candidate for B_{pa}, but is likely to be poorly defined for this stock. Factors like discarding and unreported landings should also be discussed and considered when setting the value of B_{pa}.

The discussion on reference points on fishing mortality was quite limited, and no specific values were concluded.

The results from the evaluation of the agreed harvest control rules must be seen as preliminary. However the preliminary results from the PROST software indicate that the HCR is in accordance with the precautionary approach as long as the assessment error is within the bounds used in the simulations and there is no assessment bias. PROST can, however, also include assessment bias and the workshop recommends that such simulations are made.

The simulations so far have only handled HCRs with 3-years predictions. The workshop strongly recommends that HCRs with 1-year predictions are evaluated, as they are expected to perform better. Some of the consequences of a 3-year rule are however, not expected to be properly reflected in simulations.

The plan was to carry out simulations within the FLR framework as well, but we did not manage to finish this during the workshop. The FLR framework has the advantage that it can include assessment uncertainty in a more sophisticated way then PROST and can handle more of the issues that SGMAS (ICES, 2006) recommends when evaluating HCRs. However FLR has not yet completed the development and testing of the framework. The workshop recommends that simulations by the FLR framework should be completed before the AFWG meeting in April 2006.

10 References

Åsnes, M. N. 2005. Prost User Guide. ICES Arctic Fisheries Working Group, Murmansk, Russia 19-28 April 2005. WK2.

Bogstad, B., Aglen, D., Skagen, S., Åsnes, M. N., Kovalev, Y., and Yaragina, N. A. 2004. Evaluation of the proposed harvest control rule for Northeast Arctic cod. Appendix to Report of the Arctic Fisheries Working Group, Copenhagen 4–13 May 2004. ICES C.M. 2004/ACFM:28. 475 pp.

Hirst, D. J., Aanes, S., Storvik, G., Huseby, R. B., and Tvete, I. F. 2004. Estimating catch-at-age from market sampling data using a Bayesian hierarchical model. Appl. Stat. 53:1–14.

Hirst, D., Storvik, G., Aldrin, M., Aanes, S. and Huseby, R.B. 2005. Estimating catch-at-age by combining data from different sources. Canadian Journal of Fisheries and Aquatic Sciences, 62:1377–1385.

ICES. 1971. Report of the North-East Arctic Fisheries Working Group, 1–5 February 1971. ICES CM 1971/F:3.

ICES. 1975. Report of the North-East Arctic Fisheries Working Group, Charlottenlund, 17–21 March 1975. ICES CM 1975/F:6.

ICES. 1998. Report of the Arctic Fisheries Working Group, Copenhagen 20–28 August 1997. ICES C.M. 1998/Assess:2. 366 pp.

ICES. 2005a. Report of the Arctic Fisheries Working Group, Murmansk, Russia 19–28 April 2005. ICES C.M. 2005/ACFM:20. 564 pp.

ICES. 2005b. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2005. ICES Advice 2005, Volume 3.

ICES. 2005c. Report of the Study Group on Management Strategies, Copenhagen 31 January – 4 February 2005. ICES C.M. 2005/ACFM:09. 66 pp.

ICES. 2006. Report of the Study Group on Management Strategies (SGMAS), 23–27 January 2006, ICES Headquarters. ICES CM 2006/ACFM:15.

Julious, S. A. 2001. Estimation and Inference in a changepoint regression problem. The Statisician, 50: 51–62.

Korsbrekke, K. 2006. Norwegian landings of NEA Haddock 1980–2004. ICES Workshop on Biological Reference Points for North East Arctic Haddock (WKHAD). WD1.

Patterson, K.R. 1998. A programme for calculating total international catch-at-age and weight at age. WDx, WGNPBW 1998.

Skagen, D. W., and Aglen, A. 2002. Evaluating precautionary values of fishing mortalities using long-term stochastic equilibrium distributions. Annex 7(WD 7) in: ICES Study Group on the Further Development of the Precautionary Approach to Fishery Management, Copenhagen 2-6 December 2002. ICES C. M. 2003/ACFM:09. 144 pp.

Skagen, D. W., Bogstad, B., Sandberg, P., and Røttingen, I. 2003. Evaluation of candidate management plans, with reference to North-east Arctic cod. ICES C.M. 2003/Y:03. 19 pp.

Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	EMAIL
Bjarte Bogstad	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	+47 55 23 86 81 / +47 55 23 86 87	bjarte@imr.no
Konstantin Drevetnyak	PINRO 6, Knipovitch Street 183763 Murmansk Russia	+7 8152 472 231 / +7 8152 473 331	drevko@pinro.ru
Dorleta Garcia Rodriguez (part time)	AZTI Fundazioa Txatxarremendi gartea 48395 Sukarrieta Spain	+34 602 94 00 / +34 687 00 06	dgarcia@suk.azti.es
Kjellrun Hiis Hauge	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	+47 55 23 85 90 / +47 55 23 86 87	Kjellrun.Hiis.Hauge@imr.no
Vidar Hjellvik	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	+47 55 23 86 62 / +47 55 23 86 87	Vidar.Hjellvik@imr.no
Knut Korsbrekke (Chair)	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	+47 55 23 86 38 / +47 55 23 86 87	knutk@imr.no
Yuri A. Kovalev	PINRO 6, Knipovitch Street 183763 Murmansk Russia	+7 8152 472 469 / +7 8152 473 331	kovalev@pinro.ru
Yuri M. Lepesevich	PINRO 6, Knipovitch Street 183763 Murmansk Russia	+7 8152 473 282 / +7 8152 473 331	lepesev@pinro.ru
Finlay Scott (part time)	CEFAS Pakefield Street Lowestoft Suffolk UK		f.a.scott@cefas.co.uk

Annex 2: Agenda

Agenda for the ICES Workshop on Biological Reference Points for Northeast Arctic Haddock (WKHAD)

6. March – 10. March 2006

Svanhovd, Norway

Review of revised input data from commercial fisheries

- Russian catch at age and weight at age in catch
- Norwegian catch at age and weight at age in catch
- Third countries catch at age and weight at age in catch
- handling of "coastal haddock"

Review of "tuning" data from scientific surveys

- Russian bottom trawl survey
- Norwegian bottom trawl survey
- Norwegian acoustic survey

Review of revised biological parameters from scientific surveys:

- Maturity (proportion mature at age both numbers and biomass
- Weight at age and growth

Estimation of reference points

- Choice of SR relationship
- Defining and estimating biomass reference points
- Estimation of fishing mortality reference points
- Discuss target fishing mortality candidates (range of)

Evaluation of HCR's (using both PROST and the FLR package)

- Agreed HCR
- Alternative HCR's

The evaluations should focus on the following:

- Is the HCR in accordance with the precautionary approach
- How well is the HCR performing relative to the overall objectives of high long-term yield and year to year stability in TAC.

Annex 3: WKHAD Terms of Reference 2006

A **Workshop on Biological Reference Points for North East Arctic Haddock** [WKHAD] (Chair: K. Korsbrekke, Norway) will meet in Svanhovd, Norway from 6–10 March 2006 to:

a) Review and revise input data used in assessing the North East Arctic haddock;

b) Propose biomass and fishing mortality reference points based on the most appropriate time period;

c) On the basis of the evaluation framework of management plans adopted by ACFM (SGMAS 2005, and AGLTA 2005) evaluate the proposed and candidate HCRs in relation to long term yield and year-to-year stability in TACs taking into account the spasmodic recruitment observed for this stock;

d) On the basis of the review, comment on the evaluation framework and suggest improvements.

WKHAD will report by 31 March 2006 to the attention of ACFM.

Supporting Information

PRIORITY:	High
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	Term of Reference a) The precautionary reference points are not thought to reflect the uncertainty in the assessment or predictions and need to be revised. This is necessary to do before an evaluation of the agreed harvest control rule. The time series for NEA haddock also needs to be revised. Term of Reference b) A harvest control rule (HCR) was decided at the 31st meeting of the Joint Russian-Norwegian Fisheries Commission in 2002. The joint Russian-Norwegian Commission has requested ICES to evaluate the HCR for NEA haddock. As there is not sufficient time for the revision and the evaluation at the Arctic Fisheries working group, this need to be done intersessional in a separate group/workshop. Terms of Reference c) As the agreed harvest control rule may be concluded not to be in accordance with the precautionary approach, alternative harvest control rules will be explored.
RESOURCE REQUIREMENTS:	
PARTICIPANTS:	It is suggested that the WKHAD includes participants from the following member countries: Norway and Russia.
SECRETARIAT FACILITIES:	
FINANCIAL:	Participation will be at national expense.
LINKAGES TO ADVISORY COMMITTEES:	The Group shall report to ACFM in March 2006.
LINKAGES TO OTHER COMMITTEES OR GROUPS:	ACFM, RMC, AFWG
LINKAGES TO OTHER ORGANIZATIONS:	
SECRETARIAT MARGINAL COST SHARE:	Key for general Support for WGs

Annex 4: Recommendations

We would like to recommend to the AFWG the following list of further work needed:

RECOMMENDATION	ACTION
1. Estimate the factor B_{PA}/B_{lim} using the performance of the deterministic prediction in the same way as for NEA Cod.	
2. Evaluate a modification of the agreed HCR letting a 1-year prediction replace the current use of a 3-year prediction.	
3. Incorportate natural mortality fluctuations in the simulations.	
4. Use the FLR to simulate the fishery system and focus particularly on simulating implemetation errors and their influence.	
5.	
6.	